SALMON AND STEELHEAD HABITAT LIMITING FACTORS IN THE NORTH WASHINGTON COASTAL STREAMS OF WRIA 20

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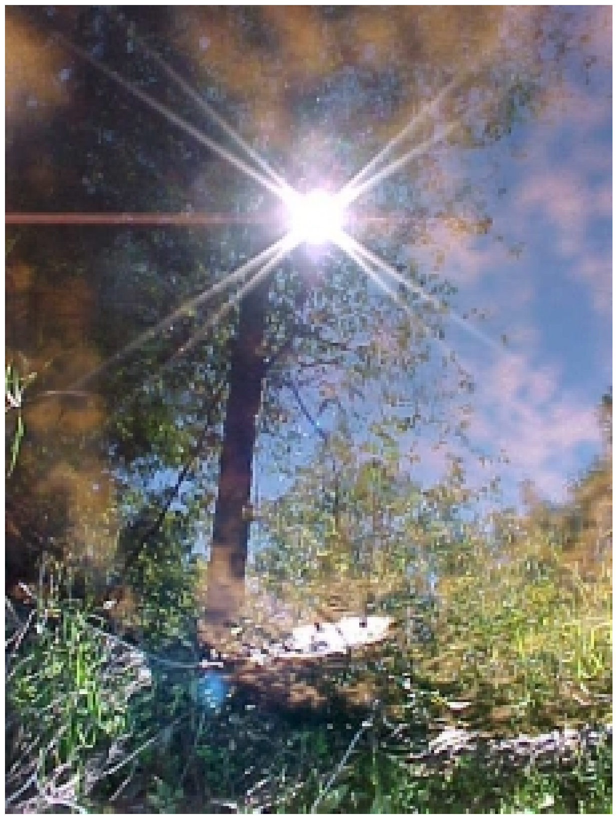

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The cover photo shows reflections from a Dickey River side slough inhabited by wild coho salmon.

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LIST OF MAPS

Several maps have been developed for this report and can be found in a separate electronic file that allows the reader to print either wall-sized maps or 11X17" maps. The reader can also simultaneously display a map and associated text. Below is a list of maps found in the WRIA 20 Map file.

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EXECUTIVE SUMMARY

As directed under Engrossed Substitute House Bill 2496 and Second Engrossed Second Substitute Senate Bill 5596, the habitat conditions of salmonid-producing watersheds within WRIA 20 are reviewed and rated. The worst habitat problems are summarized here, but an overview of all the habitat ratings is provided in Table 16 in the Assessment Chapter. The Assessment Chapter also specifies the criteria used to rate habitat conditions. Detailed discussions for each of these habitat conditions can be found within the Habitat Limiting Factors Chapter of this report. Maps of updated salmon and steelhead trout distribution, culverts and other blockages, large woody debris (LWD) and riparian conditions, and floodplain complexes were prepared and are located in a separate electronic file on this disc. This first round report examines salmon and steelhead trout habitat conditions. Later versions will address habitat issues for other salmonids.

The streams addressed in this report include all salmon- and steelhead-producing streams in the following basins: Waatch, Sooes, Ozette, Quillayute, Goodman, Mosquito, Hoh, Cedar, and Steamboat. These are discussed in order from north to south. In the north end of the WRIA, there are insufficient data to adequately assess the major habitat conditions in the Waatch and Sooes basins. However, known current problems include numerous blockages throughout the Waatch and Sooes basins with riparian road floodplain impacts for Snag Creek and Thirty Cent Creek in the Sooes. Both the Waatch and Sooes basins are greatly impacted by high water temperatures, but specific data to assess the cause of the warm temperatures were not found. Stock status for many species is depressed in these streams, suggesting a lack of marine-derived nutrients.

In the Ozette Basin, numerous “poor” habitat conditions are found and appear to be linked. The Ozette River, which drains the lake to the ocean, has been cleared of LWD. This lack of LWD has been suggested to contribute to possibly reduced water level fluctuations in Lake Ozette. Invasive plants, such as Reed canarygrass, are found along the lakeshores. Sediment is a major habitat limiting factor, resulting in degraded spawning habitat for lake spawning sockeye, but the cause of the high levels of fines is uncertain. Some of the larger tributaries draining into Lake Ozette (Umbrella Creek, Big River, Siwash Creek) are incised with banks hardened by Reed canarygrass. Fine sediment levels are high in these streams as well. Road densities are high in this basin, likely contributing to the sediment loads. Throughout the area, “poor” LWD and riparian conditions are found. Other problems include warm water temperatures, poor hydrologic maturity, an altered estuary, and a lack of marine-derived nutrients.

The Quillayute basin is the largest basin in WRIA 20. It consists of four major sub-basins: the Dickey, Soleduck, Calawah, and Bogachiel. Each sub-basin has unique habitat characteristics and problems, but all eventually drain into a significantly altered estuary. The estuary is regularly dredged, and has armored and diked banks. Estuarine habitat is extremely limited within WRIA 20, and the Quillayute estuary is the largest estuary in the WRIA. It is near known surf smelt (salmonid food item) spawning grounds and kelp and eelgrass habitat, important for salmonid rearing. Many upstream habitat problems are translated to the estuary and near shore habitat. Of particular concern are increased sedimentation and water flows. The increased flows are likely a result of several upstream problems, notably incised channels, reduced levels of LWD, and a loss of hydrologic maturity.

The Dickey sub-basin is well known for its production of coho salmon. It consists of plentiful sloughs, wetlands, and small streams, and is dominated by low gradient habitat. Because of the low-gradient nature, mass wasting is rare. However sedimentation is still a major habitat problem and is predominantly due to roads. Riparian impacts occur throughout the Dickey and are worsened because of windthrow. The strong windstorms in the winter destroy the riparian buffers left after recent timber harvest in susceptible areas. Warm water temperatures are another "poor" habitat condition throughout the Dickey sub-basin, and may be contributing to an increased distribution of squawfish, known predators of salmon. Blockages, such as culverts, are another major habitat problem in this sub-basin. The naturally low-gradient conditions result in a lack of natural blockages for salmonids, yet numerous culverts exist and should be addressed. Low water flows in the summer are thought to limit the production of salmon and steelhead. Impacts that worsen low flows include a reduction of fog drip due to a loss of older conifers within the watersheds, as well as altered wetlands due to increased road sedimentation and loss of wetland riparian vegetation. While historically, LWD was very abundant in these streams due to the low-gradients and hence, lack of downstream transport, LWD levels in the mainstems, especially in the East Fork Dickey River have recently decreased to low levels. Flooding in December, 1999 not only washed out LWD in the East Fork, but has also resulted in signs of channel instability. Riparian roads impact the floodplain conditions in Coal and Colby Creeks.

The Soleduck sub-basin lies partly within the Olympic National Park (upper reaches) and partly in timber-managed, agricultural, and residential development. The contrast between the pristine habitat conditions within the Park is sharp compared to conditions further downstream. Outside of the Park boundaries, numerous major habitat problems exist. Excessive sedimentation is a problem and stems mostly from landslides. High road densities are associated with the sedimentation problems. High levels of fine sediments are found in many Soleduck tributaries, which degrade the quality of spawning habitat. Areas of "poor" LWD and riparian conditions are other problems. The Soleduck drainage is naturally limited in wetland habitat, yet continued loss of wetlands and off-channel habitat occurs. Warm water temperatures are a problem in the summer, potentially impacting adult migration and spawning of summer chinook and a unique summer coho run. A large potential habitat problem is the over-allocation of water from the river. Contributing to summer low flows and warm water temperatures is the "poor" hydrologic maturity (loss of fog drip, change in hydrology) outside of the Park boundaries. Blockages are a known major problem within Gunderson and Tassel Creeks.

The Bogachiel sub-basin is lacking in specific data regarding many of the habitat conditions assessed in this report. Considering the number of salmon stocks and extent of salmon production from this drainage, this is a major data need. Based upon professional judgement, some of the larger habitat problems for the Bogachiel mainstem include “poor” riparian and LWD conditions downstream of the Olympia National Park boundaries, as well as an aggraded mainstem that worsens downstream. Collapsing banks are a problem along the lower mainstem, and fines from exposed clay layers likely degrade spawning habitat. Warm water temperatures are a documented habitat problem in the lower Bogachiel. Habitat conditions within the Olympia National Park (upper reaches of the Bogachiel) are excellent.

The Calawah sub-basin has extensive landslide problems, mostly relating to older roads. Side-cast roads are a particular concern, and in general high road densities are found in the South Fork Calawah and in the headwaters of the North Fork Calawah. The excessive sedimentation is thought to contribute to dewatering in Hyas Creek, the North Fork Sitkum River, and Rainbow Creek. Channel instability is a major problem throughout the sub-basin as well, and is likely a result of the excessive sedimentation, low levels of LWD and riparian road impacts. Floodplain problems such as incision and riparian roads are significant in the North Fork Calawah, Cool Creek, Devil’s Creek, the South Fork Calawah, and Hyas Creek. Levels of LWD are “poor” in many areas of the South Fork drainage, and warm water temperatures are a documented problem in the South Fork Calawah.

A significant portion of the Hoh basin lies within the Olympic National Park, but downstream of the Park, considerable habitat problems exist. Debris flows are common and devastating, resulting in scoured, incised channels with few spawning gravels and LWD. Channel incision has exposed clay layers that contribute fines into the streams, further degrading salmonid habitat. The sources of sediment loads are primarily mass wasting and road erosion. Downstream of the Park boundaries, there are many areas of “poor” LWD and riparian conditions. Access problems from culverts and cedar spalts are numerous within the Hoh basin and are a major limiting factor. The spalts have degraded water quality, riparian and channel conditions as well. Floodplain complexes are vital habitats within the Hoh basin, providing excellent rearing and winter refuge habitat. The loss and degradation of these floodplain complexes are significant impacts. Riparian roads are another extensive floodplain problem in the Hoh basin. Reductions in hydrologic maturity have occurred in areas of the middle Hoh basin, and contribute to degraded floodplain habitat as well as a potentially altered flow regime. The loss of fog drip is a major concern pertaining to low summer flows in the Hoh.

The smaller independent salmon and steelhead-producing streams include Goodman Creek, Mosquito Creek, Cedar Creek, and Steamboat Creek. Few habitat data are available for these streams, and this is a data need. However, biologists have noted that sedimentation and an altered riparian are problems in some reaches of all of these creeks. Numerous blockages from either culverts or spalts have been documented in Cedar and Steamboat Creeks. In addition, the middle reaches of Goodman Creek have low levels of LWD.

INTRODUCTION

Habitat Limiting Factors Background

The successful recovery of naturally spawning salmon populations depends upon directing actions simultaneously at harvest, hatcheries, habitat and hydro, the 4H's. The 1998 state legislative session produced a number of bills aimed at salmon recovery. Engrossed Substitute House Bill (ESHB) 2496 is a key piece of the 1998 Legislature's salmon recovery effort, with the focus directed at salmon habitat issues.

Engrossed Substitute House Bill (ESHB) 2496 in part:

- directs the Conservation Commission in consultation with local government and the tribes to invite private, federal, state, tribal and local government personnel with appropriate expertise to act as a technical advisory group;

- directs the technical advisory group to identify limiting factors for salmonids to respond to the limiting factors relating to habitat pursuant to section 8 sub 2 of this act;

- defines limiting factors as "conditions that limit the ability of habitat to fully sustain populations of salmon."

- defines salmon as all members of the family salmonidae, which are capable of self-sustaining, natural production.

The overall goal of the Conservation Commission's limiting factors project is to identify habitat factors limiting production of salmon in the state. In waters shared by salmon, steelhead trout and bull trout we will include all three. Later, we will add bull trout only waters as well as cutthroat trout.

It is important to note that the responsibilities given to the Conservation Commission in ESHB 2496 do not constitute a full limiting factors analysis. The hatchery, hydro and harvest segments of identifying limiting factors are being dealt with in other forums.

The Relative Role Of Habitat In Healthy Populations Of Natural Spawning Salmon

During the last 10,000 years, Washington State anadromous salmonid populations have evolved in their specific habitats (Miller 1965). Water chemistry, flow, and the physical stream components unique to each stream have helped shaped the characteristics of every salmon population. These unique physical attributes have resulted in a wide variety of distinct salmon stocks for each salmon species throughout the State. Within a given species, stocks are population units that do not extensively interbreed because returning adults rely on a stream's unique chemical and physical characteristics to guide them to their natal grounds to spawn. This maintains the separation of stocks during reproduction, thus preserving the distinctiveness of each stock.

Throughout the salmon's life cycle, the dependence between the stream and a stock continues. Adults spawn in areas near their own origin because survival favors those that do. The timing of juveniles leaving the river and entering the estuary is tied to high natural river flows. It has been theorized that the faster speed during out-migration reduces predation on the young salmon and perhaps is coincident to favorable feeding conditions in the estuary (Wetherall 1971). These are a few examples that illustrate how a salmon stock and its environment are intertwined throughout the entire life cycle.

Salmon habitat includes the physical, chemical and biological components of the environment that support salmon. Within freshwater and estuarine environments, these components include water quality, water quantity or flows, stream and river physical features, riparian zones, upland terrestrial conditions, and ecosystem interactions as they pertain to habitat. However, these components closely intertwine. Low stream flows can alter water quality by increasing temperatures and decreasing the amount of available dissolved oxygen, while concentrating toxic materials. Water quality can impact stream conditions through heavy sediment loads, which result in a corresponding increase in channel instability and decrease in spawning success. The riparian zone interacts with the stream environment, providing nutrients and a food web base, woody debris for habitat and flow control (stream features), filtering runoff prior to surface water entry (water quality), and providing shade to aid in water temperature control.

Salmon habitat includes clean, cool, well-oxygenated water flowing at a normal (natural) rate for all stages of freshwater life. In addition, salmon survival depends upon specific habitat needs for egg incubation, juvenile rearing, migration of juveniles to saltwater, estuary rearing, ocean rearing, adult migration to spawning areas, and spawning. These specific needs can vary by species and even by stock.

When adults return to spawn, they not only need adequate flows and water quality, but also unimpeded passage to their natal grounds. They need deep pools with vegetative cover and instream structures such as root wads for resting and shelter from predators. Successful spawning and incubation depend on sufficient gravel of the right size for that particular population, in addition to the constant need of adequate flows and water quality, all in unison at the necessary location. Also, delayed upstream migration can be critical. After entering freshwater, most salmon have a limited time to migrate and spawn, in some cases, as little as 2-3 weeks. Delays can results in pre-spawning mortality, or spawning in a sub-optimum location.

After spawning, the eggs need stable gravel that is not choked with sediment. River channel stability is vital at this life history stage. Floods have their greatest impact to salmon populations during incubation, and flood impacts are worsened by human activities. In a natural river system, the upland areas are forested, and the trees and their roots store precipitation, which slows the rate of storm water into the stream. The natural, healthy river is sinuous and contains large pieces of wood contributed by an intact, mature riparian zone. Both slow the speed of water downstream. Natural systems have floodplains that are connected directly to the river at many points, allowing wetlands to store flood water and later discharge this storage back to the river during lower flows. In a healthy river, erosion or sediment input is great enough to provide new gravel for spawning and incubation, but does not overwhelm the system, raising the riverbed and increasing channel instability. A stable incubation environment is essential for salmon, but is a complex function of nearly all habitat components contained within that river ecosystem.

Once the young fry emerge from the gravel nests, certain species such as chum, pink, and some chinook salmon quickly migrate downstream to the estuary. Other species, such as coho, steelhead, bull trout, and chinook, will search for suitable rearing habitat within the side sloughs and channels, tributaries, and spring-fed "seep" areas, as well as the outer edges of the stream. These quiet-water side margin and off channel slough areas are vital for early juvenile habitat. The presence of woody debris and overhead cover aid in food and nutrient inputs as well as provide protection from predators. For most of these species, juveniles use this type of habitat in the spring. Most sockeye populations migrate from their gravel nests quickly to larger lake environments where they have unique habitat requirements. These include water quality sufficient to produce the necessary complex food web to support one to three years of salmon growth in that lake habitat prior to outmigration to the estuary.

As growth continues, the juvenile salmon (parr) move away from the quiet shallow areas to deeper, faster areas of the stream. These include coho, steelhead, bull trout, and certain chinook. For some of these species, this movement is coincident with the summer low flows. Low flows constrain salmon production for stocks that rear within the stream. In non-glacial streams, summer flows are maintained by precipitation, connectivity to wetland discharges, and groundwater inputs. Reductions in these inputs will reduce that amount of habitat; hence the number of salmon dependent on adequate summer flows.

In the fall, juvenile salmon that remain in freshwater begin to move out of the mainstems, and again, off-channel habitat becomes important. During the winter, coho, steelhead, bull trout, and remaining chinook parr require habitat to sustain their growth and protect them from predators and winter flows. Wetlands, stream habitat protected from the effects of high flows, and pools with overhead are important habitat components during this time.

Except for bull trout and resident steelhead, juvenile parr convert to smolts as they migrate downstream towards the estuary. Again, flows are critical, and food and shelter are necessary. The natural flow regime in each river is unique, and has shaped the population's characteristics through adaptation over the last 10,000 years. Because of the close inter-relationship between a salmon stock and its stream, survival of the stock depends heavily on natural flow patterns.

The estuary provides an ideal area for rapid growth, and some salmon species are heavily dependent on estuaries, particularly chinook, chum, and to a lesser extent, pink salmon. Estuaries contain new food sources to support the rapid growth of salmon smolts, but adequate natural habitat must exist to support the detritus-based food web, such as eelgrass beds, mudflats, and salt marshes. Also, the processes that contribute nutrients and woody debris to these environments must be maintained to provide cover from predators and to sustain the food web. Common disruptions to these habitats include dikes, bulkheads, dredging and filling activities, pollution, and alteration of downstream components such as lack of woody debris and sediment transport.

All salmonid species need adequate flow and water quality, spawning riffles and pools, a functional riparian zone, and upland conditions that favor stability, but some of these specific needs vary by species, such as preferred spawning areas and gravel. Although some overlap occurs, different salmon species within a river are often staggered in their use of a particular type of habitat. Some are staggered in time, and others are separated by distance.

Chum and pink salmon use the streams the least amount of time. Washington adult pink salmon typically begin to enter the rivers in August and spawn in September and October, although Dungeness summer pink salmon enter and spawn a month earlier (WDFW and WWTIT 1994). During these times, low flows and associated high temperatures and low dissolved oxygen can be problems. Other disrupted habitat components, such as less frequent and shallow pools from sediment inputs and lack of canopy from an altered riparian zone or widened river channel, can worsen these flow and water quality problems because there are fewer refuges for the adults to hold prior to spawning.

Pink salmon fry emerge from their gravel nests around March and migrate downstream to the estuary within a month. After a limited rearing time in the estuary, pink salmon migrate to the ocean for a little over a year, until the next spawning cycle. Most pink salmon stocks in Washington return to the rivers only in odd years. The exception is the Snohomish Basin, which supports both even- and odd-year pink salmon stocks.

In Washington, adult chum salmon (3-5 years old) have three major run types. Summer chum adults enter the rivers in August and September, and spawn in September and October. Fall chum adults enter the rivers in late October through November, and spawn in November and December. Winter chum adults enter from December through January and spawn from January through February. Chum salmon fry emerge from the nests in March and April, and quickly outmigrate to the estuary for rearing. In the estuary, juvenile chum follow prey availability. In Hood Canal, juveniles that arrive in the estuary in February and March migrate rapidly offshore. This migration rate decreases in May and June as levels of zooplankton increase. Later as the food supply dwindles, chum move offshore and switch diets (Simenstad and Salo 1982). Both chum and pink salmon have similar habitat needs such as unimpeded access to spawning habitat, a stable incubation environment, favorable downstream migration conditions (adequate flows in the spring), and because they rely heavily on the estuary for growth, good estuary habitat is essential.

Chinook salmon have three major run types in Washington State. Spring chinook are generally in their natal rivers throughout the calendar year. Adults begin river entry as early as February in the Chehalis, but in Puget Sound, entry doesn't begin until April or May. Spring chinook spawn from July through September and typically spawn in the headwater areas where higher gradient habitat exists. Incubation continues throughout the autumn and winter, and generally requires more time for the eggs to develop into fry because of the colder temperatures in the headwater areas. Fry begin to leave the gravel nests in February through early March. After a short rearing period in the shallow side margins and sloughs, all Puget Sound and coastal spring chinook stocks have juveniles that begin to leave the rivers to the estuary throughout spring and into summer (August). Within a given Puget Sound stock, it is not uncommon for other chinook juveniles to remain in the river for another year before leaving as yearlings, so that a wide variety of outmigration strategies are used by these stocks. The juveniles of spring chinook salmon stocks in the Columbia Basin exhibit some distinct juvenile life history characteristics. Generally, these stocks remain in the basin for a full year. However, some stocks migrate downstream from their natal tributaries in the fall and early winter into larger rivers, including the Columbia River, where they are believed to over-winter prior to outmigration the next spring as yearling smolts.

Adult summer chinook begin river entry as early as June in the Columbia, but not until August in Puget Sound. They generally spawn in September and/or October. Fall chinook stocks range in spawn timing from late September through December. All Washington summer and fall chinook stocks have juveniles that incubate in the gravel until January through early March, and outmigration downstream to the estuaries occurs over a broad time period (January through August). A few of these stocks have a component of juveniles that remain in freshwater for a full year after emerging from the gravel nests.

While some emerging chinook salmon fry outmigrate quickly, most inhabit the shallow side margins and side sloughs for up to two months. Then, some gradually move into the faster water areas of the stream to rear, while others outmigrate to the estuary. Most summer and fall chinook outmigrate within their first year of life, but a few stocks (Snohomish summer chinook, Snohomish fall chinook, upper Columbia summer chinook) have juveniles that remain in the river for an additional year, similar to many spring chinook (Marshall et al. 1995). However, those in the upper Columbia, have scale patterns that suggest that they rear in a reservoir-like environment (mainstem Columbia upstream from a dam) rather than in their natal streams and it is unknown whether this is a result of dam influence or whether it is a natural pattern.

The onset of coho salmon spawning is tied to the first significant fall freshet. They typically enter freshwater from September to early December, but has been observed as early as late July and as late as mid-January (WDF et al. 1993). They often mill near the river mouths or in lower river pools until freshets occur. Spawning usually occurs between November and early February, but is sometimes as early as mid-October and can extend into March. Spawning typically occurs in tributaries and sedimentation in these tributaries can be a problem, suffocating eggs. As chinook salmon fry exit the shallow low-velocity rearing areas, coho fry enter the same areas for the same purpose. As they grow, juveniles move into faster water and disperse into tributaries and areas which adults cannot access (Neave 1949). Pool habitat is important not only for returning adults, but for all stages of juvenile development. Preferred pool habitat includes deep pools with riparian cover and woody debris.

All coho juveniles remain in the river for a full year after leaving the gravel nests, but during the summer after early rearing, low flows can lead to problems such as a physical reduction of available habitat, increased stranding, decreased dissolved oxygen, increased temperature, and increased predation. Juvenile coho are highly territorial and can occupy the same area for a long period of time (Hoar 1958). The abundance of coho can be limited by the number of suitable territories available (Larkin 1977). Streams with more structure (logs, undercut banks, etc.) support more coho (Scrivener and Andersen 1982), not only because they provide more territories (useable habitat), but they also provide more food and cover. There is a positive correlation between their primary diet of insect material in stomachs and the extent the stream was overgrown with vegetation (Chapman 1965). In addition, the leaf litter in the fall contributes to aquatic insect production (Meehan et al. 1977).

In the autumn as the temperatures decrease, juvenile coho move into deeper pools, hide under logs, tree roots, and undercut banks (Hartman 1965). The fall freshets redistribute them (Scarlett and Cederholm 1984), and over-wintering generally occurs in available side channels, spring-fed ponds, and other off-channel sites to avoid winter floods (Peterson 1980). The lack of side channels and small tributaries may limit coho survival (Cederholm and Scarlett 1981). As coho juveniles grow into yearlings, they become more predatory on other salmonids. Coho begin to leave the river a full year after emerging from their gravel nests with the peak outmigration occurring in early May. Coho use estuaries primarily for interim food while they adjust physiologically to saltwater.

Sockeye salmon have a wide variety of life history patterns, including landlocked populations of kokanee which never enter saltwater. Of the populations that migrate to sea, adult freshwater entry varies from spring for the Quinault stock, summer for Ozette, to summer for Columbia River stocks, and summer and fall for Puget Sound stocks. Spawning ranges from September through February, depending on the stock.

After fry emerge from the gravel, most migrate to a lake for rearing, although some types of fry migrate to the sea. Lake rearing ranges from 1-3 years. In the spring after lake rearing is completed, juveniles enter the ocean where more growth occurs prior to adult return for spawning.

Sockeye spawning habitat varies widely. Some populations spawn in rivers (Cedar River) while other populations spawn along the beaches of their natal lake (Ozette), typically in areas of upwelling groundwater. Sockeye also spawn in side channels and spring-fed ponds. The spawning beaches along lakes provide a unique habitat that is often altered by human activities, such as pier and dock construction, dredging, and weed control.

Steelhead have the most complex life history patterns of any Pacific salmonid species (Shapovalov and Taft 1954). In Washington, there are two major run types, winter and summer steelhead. Winter steelhead adults begin river entry in a mature reproductive state in December and generally spawn from February through May. Summer steelhead adults enter the river from about May through October with spawning from about February through April. They enter the river in an immature state and require several months to mature (Burgner et al 1992). Summer steelhead usually spawn farther upstream than winter stocks (Withler 1966) and dominate inland areas such as the Columbia Basin. However, the coastal streams support more winter steelhead populations.

Juvenile steelhead can either migrate to sea or remain in freshwater as rainbow or redband trout. In Washington, those that are anadromous usually spend 1-3 years in freshwater, with the greatest proportion spending two years (Busby et al. 1996). Because of this, steelhead rely heavily on the freshwater habitat and are present in streams all year long.

Bull trout/Dolly Varden stocks are also very dependent on the freshwater environment, where they reproduce only in clean, cold, relatively pristine streams. Within a given stock, some adults remain in freshwater their entire lives, while others migrate to the estuary where they stay during the spring and summer. They then return upstream to spawn in late summer. Those that remain in freshwater either stay near their spawning areas as residents, or migrate upstream throughout the winter, spring, and early summer, residing in pools. They return to spawning areas in late summer. In some stocks juveniles migrate downstream in spring, overwinter in the lower river, then enter the estuary and Puget Sound the following late winter to early spring (WDFW 1998). Because these life history types have different habitat characteristics and requirements, bull trout are generally recognized as a sensitive species by natural resource management agencies. Reductions in their abundance or distribution are inferred to represent strong evidence of habitat degradation.

In addition to the above-described relationships between various salmon species and their habitats, there are also interactions between the species that have evolved over the last 10,000 years such that the survival of one species might be enhanced or impacted by the presence of another. Pink and chum salmon fry are frequently food items of coho smolts, Dolly Varden char, and steelhead (Hunter 1959). Chum fry have decreased feeding and growth rates when pink salmon juveniles are abundant (Ivankov and Andreyev 1971), probably the result of occupying the same habitat at the same time (competition). These are just a few examples.

Most streams in Washington are home to several salmonid species, which together, rely upon freshwater and estuary habitat the entire calendar year. As the habitat and salmon review indicated, there are complex interactions between different habitat components, between salmon and their habitat, and between different species of salmon. For just as habitat dictates salmon types and production, salmon contribute to habitat and to other species.

Introduction to Habitat Impacts

The quantity and quality of aquatic habitat present in any stream, river, lake or estuary is a reflection of the existing physical habitat characteristics (e.g. depth, structure, gradient, etc) as well as the water quality (e.g. temperature and suspended sediment load). There are a number of processes that create and maintain these features of aquatic habitat. In general, the key processes regulating the condition of aquatic habitats are the delivery and routing of water (and its associated constituents such as nutrients), sediment, and wood. These processes operate over the terrestrial and aquatic landscape. For example, climatic conditions operating over very large scales can drive many habitat forming processes while the position of a fish in the stream channel can depend upon delivery of wood from forest adjacent to the stream. In addition, ecological processes operate at various spatial and temporal scales and have components that are lateral (e.g., floodplain), longitudinal (e.g., landslides in upstream areas) and vertical (e.g., riparian forest).

The effect of each process on habitat characteristics is a function of variations in local geomorphology, climatic gradients, spatial and temporal scales of natural disturbance, and terrestrial and aquatic vegetation. For example, wood is a more critical component of stream habitat than in lakes, where it is primarily an element of littoral habitats. In stream systems, the routing of water is primarily via the stream channel and subsurface routes whereas in lakes, water is routed by circulation patterns resulting from inflow, outflow and climatic conditions.

Human activities degrade and eliminate aquatic habitats by altering the key natural processes described above. This can occur by disrupting the lateral, longitudinal, and vertical connections of system components as well as altering spatial and temporal variability of the components. In addition, humans have further altered habitats by creating new processes such as the actions of exotic species. The following sections identify and describe the major alterations of aquatic habitat that have occurred and why they have occurred. These alterations are discussed as limiting factors. Provided first though, is a general description of the current and historic habitat including salmon populations.

WATERSHED CONDITION

SALMON HABITAT IN NORTH COAST WASHINGTON STREAMS

<u>Introduction</u>

This section describes the streams that produce salmon, steelhead, and bulltrout within WRIA 20 (Map 1). It includes all streams that drain into the Pacific Ocean from Cape Flattery south to, and excluding Kalaloch Creek. The largest basin in the WRIA is the Quillayute with its four major sub-basins: the Dickey, Calawah, Bogachiel, and Soleduck Rivers (Map 2). Other basins in the WRIA are the Waatch, Sooes, Ozette, and Hoh systems, as well as several small independent streams (Map 2). Within this WRIA are 569 streams and 1,355 stream miles (Phinney and Bucknell 1975).

Annual rainfall in the basin is the highest in the State, and ranges from 80 inches near the coast to 240 inches in the Olympic Mountains (McHenry et al. 1996). This region is often exposed to high wind and heavy rainstorms, which play important roles in current habitat problems located in disturbed (logged or developed) areas. Unlike many other areas of the State, this region has a significant portion of land that is located in the Olympic National Park, and this land has never been logged. In these undisturbed areas, temperate rainforest of coniferous old-growth forests are dominated by Sitka spruce in the lowlands and western hemlock with silver fir in the higher elevations. Bigleaf maple is also a component of the rainforests. The old-growth conifers can reach up to 200 feet in height, and are characterized by somewhat open canopies and low densities. The ratio of deciduous to conifer trees is 1:1000 in unmanaged areas (Kuchler 1964). These areas provide refugia for fish, playing an important role in maintaining a greater proportion of "healthy" salmon populations in this region compared to other areas in Washington State. The presence of larger areas of undisturbed forest also allows comparison between managed (timber harvest) and unmanaged conditions within the same sub-basin, providing insight into habitat conditions needed by salmon.

Historically, infrequent fires resulted in late-successional forests as the dominant forest type in this region, and reference conditions for these habitats are located within the Olympic National Park boundaries (U.S. Forest Service 1998). In windward and wet soil areas though, a mosaic of early and mid-successional stands occurred due to intense storm impact on forests.

Outside of National Park boundaries, timber harvest generally began in this region in the 1920s-1930s, using rail to transport the logs (U.S. Forest Service 1995). Road construction for log trucks began in the 1940s, and early roads often used side-cast technology on steep slopes, which still create sediment problems today. From the 1960s through the 1980s, extensive clear-cutting and road construction occurred throughout the WRIA except in the Olympic National Park, which has remained undisturbed. Present timber harvest practices have improved to increase riparian buffers and reduce road impacts. However, problems from past harvest practices continue to impact salmonid habitat.

In this chapter, recent known salmon, steelhead and bull trout distribution is discussed along with a general habitat description. Potential or unknown, but likely distribution was not included. To view salmonid distribution in WRIA 20, please refer to all the maps under the number 3. These maps are stored in a separate electronic file that is included on this disc. Salmonid distribution data was compiled from several sources, including several Watershed Analysis documents, Streamnet (WDFW), and from data and knowledge of the Technical Advisory Group (TAG) that helped develop and review this document. This first-round report addresses salmon, bulltrout and steelhead trout. Later, cutthroat trout will be added.

Sooes and Waatch Basins

The Sooes River is the largest stream in the Sooes and Waatch basins. It is 16.2 miles long and heads in low foothills, draining to the Pacific Ocean at Mukkaw Bay (Phinney and Bucknell 1975). Tidewater extends to river mile (RM) 6, and a falls blocks salmon access at RM 13.8. The Sooes River provides habitat for winter steelhead trout and fall chinook, chum, and coho salmon, although hatchery plants of non-native coho, chum, and chinook salmon may have influenced current stocks. Important salmon and steelhead producing tributaries are: Snag Creek, Pilchuck Creek, Shaffer Creek, Thirty Cent Creek, Miller Creek, and Grimes Creek. See Maps 3a-3c for the extent of known fish distribution.

Waatch Creek, Waatch River, and Educket Creek are smaller streams that produce salmon and steelhead, and lie completely within the Makah Indian Reservation. Waatch River provides about 6 miles of habitat for coho salmon and winter steelhead trout, and 3.8 miles of known habitat for chum salmon (Mike Haggerty, Makah Tribe, personal communication). Waatch Creek is known to support chum, coho, and winter steelhead spawning and rearing. Educket Creek provides about 0.5 miles of coho salmon and winter steelhead spawning and rearing habitat (Streamnet 1999).

Ozette Basin

The largest watershed in the Ozette basin is the Lake Ozette watershed. Lake Ozette is the third largest natural lake in Washington State (Phinney and Bucknell 1975), and is drained to the Pacific Ocean by Ozette River. Coal Creek is a major tributary to Ozette River. The larger tributaries that drain into Ozette Lake are Big River, Umbrella Creek, Crooked Creek, Siwash Creek, South Creek, and Quinn Creek. In addition to Ozette River and Ozette Lake, these tributaries provide spawning and rearing habitat for salmon and steelhead in the basin, and are low-elevation, low-gradient streams.

While the Olympic National Park surrounds Lake Ozette, most of the tributaries that drain into the lake are surrounded by private timber company land. It has been estimated that over 90% of the basin has been clearcut sometime in the past (McVey 1979; Blum 1984). The Makah Indian Reservation borders the lower reaches of Ozette River.

Currently, this watershed produces sockeye and coho salmon, as well as winter steelhead trout (Streamnet 1999), and historically supported chinook and chum salmon (Maps 3a-3e). The current status of chinook and chum salmon in is not well known, and if these species are still present in the basin, their numbers are believed to be very low (McHenry et al 1996). Coho salmon and winter steelhead trout are found throughout the streams listed above, including tributaries to those streams (Maps 3a and 3c). The distribution of sockeye salmon has decreased due to low population numbers, with known current habitat in the Ozette River, Ozette Lake, and possibly into the lower reaches of Umbrella Creek and Big River. Historically, it is thought that sockeye salmon had a greater range in the Lake Ozette tributaries compared to current use, and an estimate of historic range is shown in Map 3e (Mike Haggerty, Makah Tribe, personal communication). There is not agreement regarding the extent that sockeye salmon may have used Lake Ozette tributary streams.

Quillayute Basin

This basin contains about 750 linear miles of streams (Phinney and Bucknell 1975), and is often discussed in terms of its four major drainages: the Dickey, Soleduck, Bogachiel, and Calawah Rivers. The Quillayute River proper is a broad, low-gradient river, and extends for 5.6 miles in the lowest reaches of the basin. The confluence of the Soleduck and Bogachiel Rivers is located at RM 5.6, with the Dickey River entering the Quillayute River at RM 1.6. Land ownership around the Quillayute River includes the Olympic National Park, the Quileute Indian Tribe, and a few scattered farmowners.

The Dickey River is formed by the West, Middle, and East Fork Dickey Rivers, and the entire drainage is in timber production. Major tributaries include Coal and Colby Creeks. The Dickey watershed is low gradient, and consists of low, rolling hills and a vast number of wetland and side slough areas. This watershed provides the most productive coho-rearing habitat in the WRIA, and is one of the most productive coho rearing areas in the State in terms of square mile of watershed (Seiler 1999). Coho are broadly distributed throughout the Dickey sub-basin in all accessible areas (Map 3f) (Trevin Taylor, Quileute Indian Tribe, personal communication).

Fall chinook and chum salmon as well as winter steelhead trout have been known to use the mainstem Dickey River, Coal Creek, Colby Creek, and the East, Middle, and West Fork Dickey Rivers (Maps 3g-3i). The current presence and extent of fall chinook in the West Fork and Middle Fork Dickey Rivers is uncertain due to recent habitat changes and lack of data. Habitat changes may have possibly decreased the numbers of fall chinook in the East Fork Dickey (Dick Goin, personal communication). The map for fall chinook reflects recent distribution as depicted in Watershed Analysis (Rayonier 1998). Other larger tributaries include: Gunderson, Thunder, Skunk, Squaw, Sands, Stampede, and Haehule Creeks, and these support winter steelhead trout and coho salmon, although a few also provide habitat for fall chinook and chum salmon as well (Rayonier 1998). Even though these are the larger streams, all accessible areas in the Dickey watershed, from Lake Dickey to small ditches, provide rearing habitat for coho salmon.

The Bogachiel River is formed by the North and South Fork Bogachiel Rivers. These forks head in the steep terrain of the Olympic Mountains (Phinney and Bucknell 1975). The upper reaches are in the Olympic National Park, while the middle and lower reaches are primarily used for timber production and farming. In the middle and upper sections of the Bogachiel, known salmon and steelhead habitat is located in the following creeks: Bear, May, Dowans, Hemp Hill, Morganroth, Kahkwa, Devils Club, Olallie, Cultus, Hades, Kloshe, Fracker, Tumwata, Sunday, and Bee (Streamnet 1999, TAG personal communication). In the lower reaches of the Bogachiel, the most significant tributary is the Calawah River. Other important salmonid tributaries include Murphy, Maxfield, Weeden, Mill, Grader, and Dry Creeks (Maps 3f-3l).

The Bogachiel River provides spawning and rearing habitat for summer and fall chinook, coho, and chum salmon as well as for winter and summer steelhead trout (Maps 3f-3l). Small numbers of sockeye salmon spawn in the lowest reaches of the Bogachiel through the South Fork Calawah River, but these might be strays from other populations (Map 3k) (Roger Lien, Quileute Tribe, personal communication). Small numbers of pink salmon have also been noted in the Bogachiel (Phinney and Bucknell 1975), and low numbers of spring chinook have been seen spawning in early September in the upper Bogachiel River (Blaine Dalton, through Dick Goin, personal communication). All of the tributaries listed above support steelhead trout. Most also produce coho salmon and some provide habitat for chinook and chum salmon.

The Calawah River is a major tributary to the Bogachiel and is formed by the confluence of the North Fork and South Fork Calawah Rivers. These originate in the Olympic Mountains. The South Fork Calawah is the larger of the two drainages, and provides spawning and rearing habitat for coho, fall chinook, summer chinook, chum and sockeye salmon, and winter and summer steelhead trout (Maps 3f-3l). Spring chinook have also been noted in the Olympic National Park boundaries in the South Fork Calawah River (Sam Windle, through Dick Goin, personal communication). The South Fork Calawah upstream of the Sitkum River confluence lies within the boundaries of the Olympic National Park; it has not been subjected to large human-caused habitat changes. The Sitkum River and Hyas Creek are important tributaries to the South Fork Calawah River, producing fall chinook and coho salmon as well as winter and summer steelhead trout. The U.S. Forest Service owns most of the land around the Sitkum River, and although more extensive timber production has occurred in this area in the past, currently a majority of that land is in late-successional reserve, with only commercial thinning allowed (U.S. Forest Service 1998).

The North Fork Calawah provides known spawning and rearing habitat for fall chinook, summer chinook, and coho salmon, and for winter and summer steelhead trout, as well as chum salmon in its lower reaches (Maps 3f-3l) (U.S. Forest Service 1996; TAG, personal communication). The North Fork Calawah may also support limited riverine sockeye production, but information about this stock is lacking (Map 3k) (U.S. Forest Service 1996). Salmonid-producing tributaries include: Cool, Upper Cool, Devils, Albion, Short, and Canyon Creeks.

Logging began in the North Fork Calawah in the 1920s, and the dependence on rail transport limited logging to lowlands (U.S. Forest Service 1996). Road construction began in the 1940s, followed by clearcutting on steeper slopes. The early roads often used side-cast technology on steep slopes, and these are impacting current sedimentation levels. The North Fork Calawah was severely impacted by the 1951 Forks fire, which burned over 30,000 acres in 48 hours (2/3rds of the watershed). This was estimated as the largest fire in the area since about 1100 (U.S. Forest Service 1996). The fire and subsequent salvage logging resulted in an extensive loss of conifers and canopy cover and their associated functions, which are detailed later in this report.

The Soleduck drainage provides important habitat for fall chinook, summer chinook, a unique stock of summer coho, fall coho, chum, and sockeye salmon, and for winter and summer steelhead and Dolly Varden (Maps 3f-3l) (U.S. Forest Service 1995; TAG personal communication). Small numbers of pink salmon have also been noted in the Soleduck River, and a non-native hatchery run of spring chinook spawns naturally in the mainstem Soleduck River. Lake Pleasant provides rearing habitat for sockeye, kokanee, and a resident population of coho salmon (U.S. Forest Service 1995). Soleduck Falls at RM 64.9 is the upper limit of salmon and steelhead habitat in the sub-basin, and Dolly Varden have been documented only above this falls (WDFW 1998). Some of the larger salmonid-producing tributaries include: Gunderson, Tassel, Shuwah, Maxfield, Swanson, Lake, Bockman, Beaver, Rainey, Bear, Snider, Kugel, Camp, Goodman, Tom, and Alckee Creeks. Gunderson Creek drains the same wetland area as the Gunderson Creek in the Dickey sub-basin. Generally, the upper watershed drains mountainous terrain, with steep gradient tributaries. The lowlands are flat or gently rolling hills.

The Soleduck watershed consists of 22.5% private lands, 13.4% Washington State DNR lands, 31.9% Olympic National Park, and 32.1% Olympic National Forest ownership (U.S. Forest Service 1995). The lower Soleduck is surrounded primarily by land in private and State timber production, and is currently in its second or third timber rotation. The middle reaches lie within the Olympic National Forest, and the upper reaches within the Olympic National Park (Phinney and Bucknell 1975). The South Fork Soleduck lies within the Olympic National Forest. More than half of the land within the Olympic National Forest is in Late Successional Reserve, and the remaining Forest Service lands are in an Adaptive Management Area. However, nearly all of watershed outside of the Olympic National Park has been harvested for timber, with clear-cuts the most common form of harvest (U.S. Forest Service 1995).

In addition to the timber harvest patterns described for the WRIA, the Soleduck watershed has been exposed to other impacts. In 1921, the "Big Blow" or "21 Blow" was a huge windstorm (wind speeds exceeding 100 mph) that downed forests in the area. Fires have been numerous as well, and the Forks Fire led to increased road construction to facilitate salvage logging. The lower Soleduck watershed has significant agricultural use. Also, tens of thousands of tons of concrete were used to develop the nearby Quillayute Air Base in WWII (U.S. Forest Service 1995).

Hoh Basin

The Hoh River is a large, glacially influenced river with an extensive, active floodplain associated with numerous spring-fed terrace tributaries (McHenry et al. 1996). The Olympic National Park comprises 65% of the Hoh watershed, with the section of the Hoh River lying outside of Park boundaries extending from RM 1.5 to 29.6. The headwaters lie in the Olympic National Park and drain Bailey Range and the north slope of Mount Olympus (Phinney and Bucknell 1975). The South Fork Hoh is a major tributary that joins the Hoh River at RM 30. Other known salmonid-producing tributaries include Slide, Falls, Mt Tom, Jackson, Taft, Snider, East Twin, Canyon, Spruce, Dismal, Pole. Tower, Lindner, Clear, Willoughby, Elk, Alder, Winfield, Hell Roaring, Lost, Pins, Anderson, Nolan, Braden, and Fossil Creeks.

The Hoh watershed provides habitat for coho, fall chinook, spring/summer chinook, chum salmon and for winter and summer steelhead trout. Distribution of salmon and steelhead trout can be viewed on Maps 3m-3r. Bull trout spawn in the North and South Fork Hoh Rivers, and utilize downstream areas as well. The Hoh watershed is believed to support the largest char population on the coast (WDFW 1998). The Hoh spring/summer chinook stock is the largest population of early timed chinook on the Olympic Peninsula, and this stock spawns primarily within the Olympic National Park boundaries (McHenry et al. 1996).

Two independent streams that drain north of the Hoh basin also produce salmon and steelhead trout in this basin. Goodman Creek supports winter steelhead trout as well as coho and fall chinook salmon (Maps 3m-3o). Mosquito Creek produces coho salmon and winter steelhead trout. The lower reaches of these streams lie within the Olympic National Park, while the middle and upper reaches are surrounded by private and state timberlands.

Cedar Creek and Steamboat Creek are smaller independent streams located to the south of the Hoh River. They provide habitat for winter steelhead trout and coho salmon (Maps 3m and 3o).

CONDITION OF NATURAL SPAWNING SALMON POPULATIONS IN WRIA 20

Salmon and steelhead stocks in the North Coastal streams are listed in Table 1 below along with their status as reported in the Salmon and Steelhead Stock Inventory (SASSI) (WDFW and WTIT, 1993), in Nehlsen et al. (1991), and in McHenry et al. (1996). The information in McHenry et al. (1996) is the most current assessment. Nehlsen et al. (1991) had three categories to describe population condition, and did not list stocks that were considered to be healthy. Their categories are "high risk of extinction", "moderate risk of extinction", and "of special concern". "Of special concern" applied to stocks for which: minor disturbances could provide a threat, believed to be depleted but lacking specific information, if large numbers of non-native fish were present and could interbreed with the stock, or if the population contained unique characters that required protection.

Salmon and Steelhead Stock Status in the Waatch, Sooes, and Ozette Basins

One of the stocks in these basins, Ozette sockeye, has been listed as "threatened" under the Endangered Species Act. The historical abundance of Ozette sockeye is poorly documented (Mike Haggerty, Makah Tribe, personal communication). Kemmerich (1945) estimated the run size entering the lake at around 4,000-6,500 fish, and these counts may have occurred upstream from Ozette River fisheries. Dlugokenski at al. (1996) reported much greater numbers of sockeye (14,556-17,638) over a three-year period from 1949-1951. However, these estimates appear to come from verbal reports, and the levels are disproportionately large relative to other recorded years, raising doubt about the accuracy of the estimates. Recent abundance estimates using an underwater video camera, indicate that the run size has ranged from 1133-2076 in the last four years (1996-1999) (Mike Haggerty, Makah Tribe, personal communication). Overall abundance appears to have declined from historical levels. Currently, tributary spawning is limited to Umbrella Creek and Big River, and the spawning distribution along the shores of the lake has been reduced.

Also in the mid-1950s, Ozette fall chinook and fall chum harvest levels sharply declined. Coho salmon returns have also declined since the 1950s, but not as sharply as other salmon species. Most of the stock status estimates are based upon harvest levels. In the past, spawner surveys for all salmonid species in these basins have been infrequent, but beginning in 1995, intensive survey efforts have occurred in the major tributaries that drain into Lake Ozette (Mike Haggerty, Makah Tribe, personal communication). Because of the increased effort, more accurate fish distribution maps will be developed in the near future.

Salmon and steelhead stocks in the Waatch and Sooes basins are described mostly as "unknown status" (WDFW and WTIT 1993). McHenry et al. (1996) listed Sooes fall chum as critical though. Salmon and steelhead spawners in the Sooes Basin is monitored by the Makah Indian Tribe. A baseline habitat study is planned for the Sooes and Waatch Basins in FY 2001 and 2002 (Mike Haggerty, Makah Tribe, personal communication).

Salmon and Steelhead Stock Status in the Quillayute Basin

All of the native early-timed (summer) chinook stocks in the Quillayute basin are considered "threatened" by McHenry et al. (1996). In contrast, only one fall chinook stock (Dickey) was listed as "threatened" in this same report. The other fall chinook stocks were described as "healthy with increasing trends". These same chinook stocks were described as "healthy" in the SASSI report (WDFW and WWTIT 1993). Local citizens have noted the presence of spring chinook in the South Fork Calawah and upper Bogachiel Rivers, but no specific information regarding these fish currently exists. This is a data need.

The status of coho salmon in the Quillayute is mixed. The unique summer coho stock in the Soleduck Watershed was listed as "threatened" in McHenry et al. (1996), while fall coho in the Dickey and Soleduck Rivers was described as "stable". Bogachiel/Calawah fall coho were listed as "threatened" (McHenry et al 1996). All of the Quillayute basin coho salmon stocks were described as "healthy" in the SASSI report (WDFW and WWTIT 1993).

The Dickey River is noteworthy for high levels of wild coho production, and the coho stock is the only assessed salmon and steelhead stock within the Dickey that was not described as "threatened" in McHenry et al. (1996). Seiler (1999) estimated the average coho smolt production from the Dickey as 818 smolts/mi^2, the fourth most productive system out of those measured in Western Washington. In this same comparison, the Bogachiel River produced about half the level of smolts (417/mi^2). However, even though the Dickey River coho have been recently described as "productive", a long-time local resident, Dick Goin, has noticed that they are not nearly as numerous as they were historically.

Winter steelhead trout were described as either "healthy" or "stable" except for those in the Dickey, which were listed as "threatened" (McHenry et al. 1996). The SASSI report lists all Quillayute winter steelhead stocks as "healthy" and all summer steelhead stocks as "unknown" (WDFW and WWTIT 1993).

Sockeye and chum salmon are present in the Quillayute, but their status is described as "unknown" in SASSI (WDFW and WWTIT 1993). These stocks are not mentioned in the other two reports.

A resident char population has been documented above Soleduck Falls (RM 65.5), but its current status is unknown (Mongillo 1993). There are no known reports of char downstream of the falls.

Salmon and Steelhead Stock Status in the Hoh Basin

All of the salmon and steelhead stocks within the Hoh are considered to be native with few introductions of outside stocks (McHenry et al. 1996). The Hoh River spring/summer chinook stock is considered to be "stable", and much of its habitat is located in the relatively undisturbed Olympic National Park. However, some recent decline has been noted, which is significant because of a lack of response from recent reductions in northern Canadian ocean fisheries (Jim Jorgensen, Hoh Tribe, personal observation). Fall chinook were defined as "healthy" by McHenry et al (1996), but recent information shows a slightly declining terminal adult run, which is more significant because of a lack of response from recent reductions in northern Canadian ocean fisheries (Jim Jorgensen, Hoh Tribe, personal observation). A decline of fall chinook spawners is evident in tributaries (such as Alder and Owl Creeks) and side-channels of the middle Hoh that have been impacted by sluice-outs and river channel instability.

Habitat changes in the middle Hoh (the section outside of the Olympic National Park) are thought to be responsible for declines in coho salmon as well. Coho are the most abundant salmon in the Hoh, but escapements since 1992 have declined (McHenry et al. 1996). Very low returns occurred in 1993, 1994, and 1997 because of low ocean smolt survival. Also, in the adjacent Clearwater River, there has been a low number of smolts per female spawner produced from the 1997 brood escapement, despite low escapement density, similar to the escapement level in the Hoh River that year (Jim Jorgensen, Hoh Tribe, personal communication). Fall chum salmon have probably never been numerous due to the limited estuary, and have shown a long-term decline (McHenry et al. 1996). The highest catch level of chum in the Hoh was 218 fish.

Hoh winter steelhead are larger-sized and more numerous than summer steelhead (McHenry et al. 1996). Quinault River steelhead are annually planted in the Hoh basin, but have an earlier return timing and a heavy exploitation rate which results in minimal interaction with wild fish. Hoh winter steelhead have been described as "stable", but there has been a declining trend since the early 1980s. This trend has been attributed to poor marine survival (Cooper and Johnson 1992). Less is known about summer steelhead population levels. They spawn in the upper reaches and population levels are considered to be naturally lower than winter steelhead due to limited suitable habitat and competition with winter steelhead (McHenry et al. 1996).

The status of char in the Hoh basin is unclear. The largest char population on the Washington coast was believed to originate from the Hoh basin (Mongillo 1993), but current levels appear to be low (Brenkman and Meyer 1999).

Fall coho salmon and winter steelhead trout have been documented in Goodman Creek, Mosquito Creek, Cedar Creek, and Steamboat Creek. The status of these stocks is unknown, and remains a data need.

Table 1. North Coast salmon and steelhead stocks and status.

Stock	Nehlsen et al. (1991)	SASSI Status (WDFW and WTIT, 1993)	McHenry et al. 1996 Status
Sooes fall chinook		Unknown (hatchery produced)	
Sooes fall chum		Unknown	Critical
Sooes/Waatch coho		Unknown	Unknown
Sooes/Waatch winter steelhead		Unknown	
Ozette fall chinook	High risk of extinction	Extinct	Critical
Ozette fall chum	High risk of extinction	Unknown	Threatened
Ozette coho	Of special concern	Unknown	Threatened
Ozette sockeye	Moderate risk of extinction	Depressed	Critical
Ozette winter steelhead		Unknown	
Soleduck spring chinook		Healthy (augmented by hatchery, non-native)	

Soleduck summer chinook		Healthy	Threatened
Soleduck fall chinook		Healthy	Healthy, increasing trend
Quillayute/Bogachiel summer chinook		Unknown	Threatened (called "spring chinook")
Quillayute/Bogachiel fall chinook		Healthy	Healthy, increasing trend
Calawah summer chinook		Unknown	Threatened
Calawah fall chinook		Healthy	Healthy, increasing trend
Dickey fall chinook		Healthy	Threatened
Quillayute chum		Unknown	
Soleduck summer coho		Healthy	Threatened
Dickey fall coho		Healthy	Stable
Soleduck fall coho		Healthy	Stable
Bogachiel fall coho		Healthy	Threatened
Calawah fall coho		Healthy	Threatened
Quillayute sockeye		Unknown	

Soleduck sum. steelhead		Unknown	
Bogachiel summer steelhead		Unknown	
Calawah summer steelhead		Unknown	
Quillayute/Bogachiel winter steelhead		Healthy	Healthy, decreasing trend
Dickey winter steelhead		Healthy	Threatened
Calawah winter steelhead		Healthy	Stable
Soleduck winter steelhead		Healthy	Stable
Hoh spring/summer chinook		Healthy	Stable (stable, some recent decline, J.Jorgensen)
Hoh fall chinook		Healthy	Healthy, increasing trend (healthy, slightly declining terminal adult run, J. Jorgensen)
Hoh fall chum		Long-term decline	
Hoh fall coho		Healthy	Healthy, decreasing trend
Hoh summer steelhead		Unknown	

Hoh winter steelhead		Healthy	Stable (healthy, decreased significantly from the 1980s to 1990s, J. Jorgensen)
Goodman/Mosquito coho		Unknown	
Goodman winter steelhead		Unknown	
Mosquito winter steelhead		Unknown	

HABITAT LIMITING FACTORS BY SUB-BASIN

Categories of Habitat Limiting Factors used by the Washington State Conservation Commission

The following is a list and description of the major habitat limiting factor categories that are used to organize the Limiting Factors Reports. Although these categories overlap with each other, such that one habitat problem could impact more than one habitat limiting factor category, they provide a reasonable structure to assess habitat conditions within a basin or sub-basin. Within each category are one or more data types that provide a means to assess each category.

Loss of Access to Spawning and Rearing Habitat

This category includes culverts, tide gates, levees, dams, and other artificial structures that restrict access to spawning habitat for adult salmonids or rearing habitat for juveniles. Additional factors considered are low stream flow or temperature conditions that function as barriers during certain times of the year.

Floodplain Conditions

Floodplains are relatively flat areas adjacent to larger streams and rivers that are periodically inundated during high flows. In a natural state, they allow for the lateral movement of the main channel and provide storage for flood waters, sediment, and large woody debris. Floodplains generally contain numerous sloughs, side-channels, and other features that provide important spawning habitat, rearing habitat, and refugia during high flows. Impacts in this category includes direct loss of aquatic habitat from human activities in floodplains (such as filling), disconnection of main channels from floodplains with dikes, levees, revetments, and riparian roads, and impeding the lateral movement of flood flows with dikes, riparian roads, levees, and revetments. Disconnection can also result from channel incision caused by changes in hydrology or sediment inputs.

Streambed Sediment Conditions

Changes in the inputs of fine and coarse sediment to stream channels can have a broad range of effects on salmonid habitat. Increases in coarse sediment can create channel instability and reduce the frequency and volume of pools, while decreases can limit the availability of spawning gravel. Decreased channel stability is often noted by analyzing aerial photographs for widespread channel changes or by measuring scour. Increases in fine sediment can fill in pools, decrease the survival rate of eggs deposited in the gravel (through suffocation), and lower the production of benthic invertebrates. As part of this analysis, increased sediment input from landslides, roads, agricultural practices, construction activities is examined as well as decreased gravel availability caused by dams and floodplain constrictions. This category also assesses instream habitat characteristics that are related to sedimentation and sediment transport, such as bank stability and erosion and large woody debris (LWD).

Riparian Conditions

Riparian areas include the land adjacent to streams, rivers, and nearshore environments that interacts with the aquatic environment. This category addresses factors that limit the ability of native riparian vegetation to provide shade, nutrients, bank stability, and large woody debris. Riparian impacts include timber harvest, clearing for agriculture or development, and direct access of livestock to stream channels. This section also examines future LWD recruitment, where data are available, and the abundance and depth of pool habitat.

Water Quality

Water quality factors addressed by this category include stream temperature, dissolved oxygen, and toxics that directly affect salmonid production. Turbidity is also included, although the sources of sediment problems are addressed in the streambed sediment category. In some cases, fecal coliform problems are identified because they may serve as indicators of other impacts in a watershed, such as direct animal access to streams.

Water Quantity

Changes in flow conditions can have a variety of effects on salmonid habitat. Decreased low flows can reduce the availability of summer rearing habitat and contribute to temperature and access problems, while increased peak flows can scour or bury spawning nests. Other alterations to seasonal hydrology can strand fish or limit the availability of habitat at various life stages. All types of hydrologic changes can alter channel and floodplain complexity. This category addresses changes in flow conditions brought about by water withdrawals, the presence of roads and impervious surfaces, the operation of dams and diversions, alteration of floodplains and wetlands, and changes in hydrological maturity (vegetation age).

Estuarine and Nearshore Habitat

This category addresses habitat impacts that are unique to estuarine and nearshore environments. Estuarine habitat includes areas in and around the mouths of streams extending throughout the area of tidal influence on fresh water. These areas provide especially important rearing habitat and an opportunity for transition between fresh and salt water. Impacts include loss of habitat complexity due to filling, dikes, and channelization; and loss of tidal connectivity caused by tidegates. Nearshore habitat includes intertidal and shallow subtidal saltwater areas adjacent to land that provide transportation and rearing habitat for adult and juvenile fish. Important features of these areas include eelgrass, kelp beds, cover, large woody debris, and the availability of prey species. Impacts include bulkheads, overwater structures, filling, dredging, and alteration of sediment processes. Water quality issues of the estuarine or nearshore environment, such as toxics, dissolved oxygen, and water temperatures are included in this section, as well as the presence of significant baitfish spawning sites. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as marine mammals and birds. The introduction of non-native species specific to the estuary, such as *Spartina*, is included in this section.

<u>Lake Habitat</u>

Lakes can provide important spawning and rearing for salmonids. This category includes impacts that are unique to lake environments, such as the construction of docks and piers, increases in aquatic vegetation, the application of herbicides to control plant growth and changes in lakeshore vegetation. Also included are habitat changes that have promoted the increase in opportunistic predators on salmon, such as squawfish (northern pike minnow).

<u>Biological Processes</u>

This category addresses impacts to fish brought about by the introduction of exotic plants and animals and also from the loss of ocean-derived nutrients caused by a reduction in the amount of available salmon carcasses. It also includes impacts from increased predation or competition and loss of food-web function due to habitat changes.

Rating Habitat Conditions

The major goal of this project is to identify the habitat conditions that should be restored or conserved for the best benefit of salmonid production. Often, numerous habitat degradations can be found within a watershed, and some have a greater impact on salmonids than others. To help identify the most significant habitat limiting factors, the Conservation Commission developed a system to rate the above-described habitat limiting factor categories as “good”, “fair”, or “poor”. This is useful to allow comparisons of limiting factors within a watershed, as well as provide the same general standards to rate conditions across the state for this project. These ratings are not intended to be used as thresholds for regulatory purposes. The details and data sources for the standards are described in the Assessment Chapter.

Habitat Limiting Factors in the Waatch, Sooes, and Ozette Basins

Loss of Access for Anadromous Salmonids in the Sooes, Waatch, and Ozette Basins

Data Sources

The Salmonid Screening, Habitat Enhancement and Restoration Division of WDFW maintains a database on fish passage problems and this was used as a data source (SSHEAR 1998), as well as the Washington State Department of Transportation list of barriers (DOT 1999). In addition, professional knowledge by the Technical Advisory Group (TAG) members led to the inclusion of barriers that were not in the published databases. Still, this list should be considered incomplete until more surveys are completed. The amount of habitat blocked was assessed to rate currently known access conditions. Details of the rating criteria are in the Assessment Chapter of this report. Access is rated "poor" for the Waatch basin, Thirty Cent Creek (Sooes basin), and Boe Creek (Ozette basin). Overall, both the Sooes and Ozette basins rated "fair". In addition to the blockages listed below, a hatchery weir on the Sooes River blocks passage of adult salmon. However, natural escapement is allowed upstream of the weir after hatchery egg needs are met.

Blockages in the Waatch, Sooes, and Ozette Basins

These blockages should be field verified prior to restoration planning. Priority order was not assigned.

1) A perched culvert on an unnamed tributary to the Sooes River (NE quarter of sec 34 T32R15W) is a partial blockage to adult coho and steelhead and a total blockage to juveniles. Blocked habitat includes a large (>10 acre) wetland and a couple thousand feet of significant spawning habitat. (Mike Haggerty)

2) Roughly more than 10 acres of wetland and 0.3 miles of 1-2% gradient stream access is blocked to coho, steelhead, and cutthroat by a perched pipe at RM 1.01 in a right bank tributary (Bear Creek, 20.0007) to the Waatch River RM 1.05. (Mike Haggerty)

3) Roughly more than 10 acres of wetland access is blocked to coho and cutthroat by a perched pipe at the wetland outlet, in stream number 20.0015X at RM 0.08. (Mike Haggerty)

4) A perched pipe on the wetland outlet at RM 0.2 in Thirty Cent Creek (20.0027) blocks over three acres of wetland and a total of about 0.8 miles of stream habitat important for coho, steelhead, and cutthroat. The stream habitat includes about 0.5 miles of 2-4% gradient and 0.3 miles of unconfined 1-2% gradient stream. (Mike Haggerty)

5) A perched pipe on the wetland outlet at RM 0.22 in Thirty Cent Creek (20.0027) blocks over three acres of wetland and about 0.8 miles of stream habitat important for coho, steelhead, and cutthroat. The stream habitat includes about 0.5 miles of 2-4% gradient and 0.3 miles of unconfined 1-2% gradient stream. (Mike Haggerty)

6) Over 2.25 miles of coho, steelhead, and cutthroat spawning and rearing habitat are blocked by a small dam at RM 0.3 in Educket Creek (20.0010). The stream habitat includes about 1.5 miles of 2-4% gradient and 0.75 miles of 1-2% gradient stream. (Mike Haggerty)

7) Over 1.5 miles of coho, steelhead, chum, and cutthroat spawning and rearing habitat are blocked by a small dam at RM 0.45 in Waatch Creek (20.0004). (Mike Haggerty)

8) An undersized culvert at RM 0.5 on Shafter Creek (tributary to the Sooes River) has chronic problems with clogged debris into the upstream end of the pipe. This is a complete blockage for adult coho and steelhead, blocking over 1 mile of unconfined, low-gradient good spawning and rearing habitat. (Mike Haggerty)

9) A perched culvert on a side-channel/tributary to the Waatch River acts as a partial blockage to juvenile salmonids and restricts access to about 0.8 miles of low gradient inter-tidal rearing area and numerous small wetlands (Mike Haggerty).

10) A failing perched culvert partially blocks about 4,000 feet of moderately confined coho and steelhead spawning and rearing habitat on a left bank tributary to Umbrella Creek near RM 7 (SW quarter of sec 12 T31R15W). (Mike Haggerty)

11) In Miller Creek (20.0026) near RM 0.4, a perched pipe on Sooes mainline blocks about 0.7 miles of coho, steelhead, and cutthroat habitat. This includes about 0.4 miles of 2-4% gradient, moderately confined stream and 0.3 miles of 1-4% gradient, moderate confined habitat. (Mike Haggerty)

12) A perched culvert on Tyler Creek (tributary to the Sooes River) is a partial barrier to adult coho and steelhead and a total blockage to juveniles. It blocks about 0.5 miles of unconfined, 1-3% gradient spawning and rearing habitat. (Mike Haggerty)

13) In Grimes Creek (20.0025) near RM 0.3, a perched pipe on Sooes mainline blocks about 0.4 miles of coho, steelhead, and cutthroat habitat (2-4% gradient). (Mike Haggerty)

14) In stream 20.0056, a partially impassable fish-way at the road crossing near RM 0.12 blocks at least 0.35 miles of coho, steelhead, and cutthroat habitat (2-4% gradient). (Mike Haggerty)

15) On stream 20.0038 near RM 0.35, an undersized perched pipe blocks about 0.31 miles of coho, steelhead, and cutthroat habitat (0.21 miles of 2-8% gradient, moderately confined channel and 0.1 mile of 4-8% gradient, moderately confined channel). (Mike Haggerty)

16) A perched pipe acts as a partial barrier to steelhead and coho in a left bank tributary to Big River near RM 7 (SE quarter of sec 20 T31R14W). There is a significant amount of low gradient stream and wetland habitat upstream of this culvert. (Mike Haggerty)

17) A perched pipe acts as a partial barrier to steelhead and coho in a left bank tributary to Big River near RM 7 (NE quarter of sec 29 T31R14W). There is a significant amount of low gradient stream and wetland habitat upstream of this culvert. (Mike Haggerty)

18) In stream 20.0039 near RM 0.25, an undersized perched pipe blocks at least 0.15 miles of coho, steelhead, and cutthroat habitat (4-8% gradient). (Mike Haggerty)

Floodplain Impacts in the Waatch, Sooes, and Ozette Basins

The most common floodplain impact in the Waatch, Sooes, and Ozette basins are riparian roads. Some of these roads closely parallel the streams, acting as dikes, disconnecting potential off-channel habitat, and increasing sediment inputs into the stream. The most heavily impacted streams are listed in Table 2. Using the rating criteria outlined in the Assessment Chapter, several streams rated "poor" for floodplain impacts, including Snag Creek, Thirty Cent Creek, Umbrella tributary 20.0053, Umbrella tributary 20.0056, Big River, and Solberg Creek. Of these, Big River has the greatest floodplain impact, with about 6 miles of mainstem riparian road, in addition to 0.2 miles of impact in a tributary.

Channel incision is another floodplain problem in these basins, especially in the lower reaches and in the headwaters of South Creek and the lower reaches of Big River (Rayonier 1999) as well as in Umbrella Creek and Coal Creek (Joel Freudenthal, Clallam County, personal communication). Historically, Big River was an unconfined meandering stream with extensive logjams (Kramer 1953; Forests and Fish Caucus 1999). The large wood was removed in the 1950s, which increased stream energy and scour. Currently, Big River is incised and the increased bank disturbance has resulted in invasive Reed canarygrass (Mike Haggerty, Makah Tribe, personal communication). The canarygrass has in turn, hardened the banks, further confining the channel. This results in a "poor" rating for floodplain condition in these areas.

Table 2. Riparian Roads in the Sooes, Waatch and Ozette Basins.

Stream	Range (RM) Impacted	Species Impacted	Habitat Rating
Waatch River	0.7-1.7	Coho, steelhead	Fair
Snag Cr. (Sooes)	1.3-2.7	Coho, steelhead	Poor
Sooes Trib 0035	0.4-0.6	Coho, steelhead	Fair
Thirty Cent Cr. (Sooes)	0.2-0.8	Steelhead	Poor
Ozette Sub-Basin:			
Umbrella Trib. 0053	0.0-0.3	Coho	Poor
Umbrella Trib. 0056	Most of the lower mile	Coho	Poor
Umbrella Cr.	6-6.3, 8-8.2	Coho	Good
Big River	0.3-3.8, most of 4.6-7.1. Hoko-Ozette Rd.	Coho, steelhead	Poor
Boe Cr. (Big R.)	0.4-0.6	Coho	Fair
Solberg Cr. (Big R.)	0.2-1.4	Coho, steelhead	Poor

Streambed Sediment Conditions in the Waatch, Sooes, and Ozette Basins

Streams on the Olympic Peninsula have naturally high rates of erosion that have been accelerated by deforestation and road building (SCS 1984). Between 1940 and 1973, clearcutting occurred in 25% of the Ozette basin (Bortleson and Dion 1979), with another 60% clear-cut by 1984 (Blum 1988). Logging in the southern and lower eastern sides of the lake occurred much later than elsewhere in the basin (Dick Goin, personal communication). In the Ozette basin, these streambed/sediment impacts are associated with the privately owned land surrounding the tributaries that drain into the lake from the north and east (McVey 1979, Blum 1984). The Olympic National Park owns a strip of land to the west of Lake Ozette, as well as land surrounding the lake, and that land is relatively pristine.

In the area to the north and east of the lake, road densities are high, and the quality of road surfacing is very poor, contributing to surface erosion problems (Dlugokenski et al. 1981). Road density in the Umbrella Creek Watershed is 4.4 miles/mi^2 (Dlugokenski et al. 1981), and in the Big River watershed, road densities averaged 3.78 mi/mi^2 (Mike Haggerty, Makah Tribe, personal communication). These levels result in a "poor" rating of habitat for the road density category (see the Assessment Chapter for details of rating standards). The road density estimates are conservative, because just in the last 2-3 years, 10.1 miles of new roads have been constructed in the Ozette drainage (Mike Haggerty, Makah Tribe, personal communication).

Spawning gravels are present along the lower and middle reaches of the main tributaries to Lake Ozette (Bortleson and Dion 1979), but these gravels are inundated with fine sediment. Fine sediment levels in Lake Ozette tributaries average 18.7% (Table 3) (McHenry et al. 1994), well above the western Washington target condition of less than 11% (Peterson et al. 1992). This results in "poor" fine sediment ratings for Big River, Umbrella Creek, Siwash Creek, North Fork Crooked Creek, and South Fork Crooked Creek. Siltation has caused gravels to cement, greatly reducing spawning habitat quality (McHenry et al. 1994).

Generally, LWD (large woody debris) levels are "poor" in lower Big River, in most of Siwash Creek, and in parts of South Fork Crooked Creek. Quantities of LWD were rated as "good" in Crooked Creek, North Fork Crooked Creek, parts of South Fork Crooked Creek, lower Siwash Creek, middle South Creek, and the middle reaches of Big River (Rayonier 1999). The quantity of LWD in the Ozette River was considerably reduced from the 1950s through early 1980s (Kramer 1953; Dick Goin, personal communication; Joel Freudenthal, Clallam County, personal communication). During the 1950s, about 30-36 very large logjams were removed from Ozette River, with some logs are large as 6-8 feet in diameter (Kramer 1953). Big River was also "cleaned" of LWD in the early 1950s, from RM 2-6 (Kramer 1953). Active removal of LWD occurred in the Sooes and Waatch (McHenry et al. 1996). However, other than the information listed above, specific quantities of current LWD remains a data need for many of the streams in the Sooes, Waatch, and Ozette basins.

Table 3. Percent fine sediments in Ozette streams (McHenry et al. 1996).

Stream	Percent Fines (0.85 mm)	Habitat Rating
Upper Big River	18.4%	Poor
Lower Big River	18.5%	Poor
Upper Umbrella Creek	18.4%	Poor
Middle Umbrella Creek	18.4%	Poor
Lower Umbrella Creek	18%	Poor
Siwash Creek	26.2%	Poor
Trout Creek	15.2%	Fair
Boe Creek	15.2%	Fair
Crooked Creek	14.4%	Fair
North Fork Crooked Creek	25.5%	Poor
South Fork Crooked Creek	18.2%	Poor

Riparian Conditions in the Waatch, Sooes and Ozette Basins

The riparian zone adjacent to many of the tributaries that feed into Lake Ozette has been converted from historical old growth conifer to predominately red alder stands, which will be unable to supply adequate large woody debris in the future (Jacobs et al. 1996). South Creek had a mix of "fair" and "poor" riparian in its lower reaches and a "good" riparian further upstream (Map 6a) (Rayonier 1999). The analyzed area of Quinn Creek rated "fair" for riparian condition, and Crooked Creek had a mostly "poor" to "fair" riparian along its mainstem, with a "good" riparian in the North Fork and "fair" to "good" in the South Fork (Rayonier 1999). "Poor" to "fair" riparian conditions exist in Big River and Dunham Creek. While most of the lowest reaches of Umbrella Creek rated "poor" for riparian condition. The riparian condition for Ozette River, located within the Olympic National Park, has been rated as "good", although about 850' of the north bank reach exiting the lake has a greatly reduced riparian (Joel Freudenthal, Clallam County, personal communication).

Riparian condition assessment for streams in the Waatch and Sooes sub-basins, as well as for reaches in the Ozette basin other than those listed above, is in progress (Mike Haggerty, Makah Tribe, personal communication).

Water Quality in the Sooes, Waatch, and Ozette Basins

High water temperatures and low dissolved oxygen levels have been recorded in the Sooes River (DOE 1998). The Waatch River and its major tributary, Educket River, have also exceeded State water quality standards for dissolved oxygen and pH, and in the case of the Waatch River, water temperature as well. Hobuck Creek, a small independent stream, has also exceeded State water temperature and dissolved oxygen standards. These recorded exceedances result in a “poor” water quality rating for the Sooes, Waatch, and Educket Rivers.

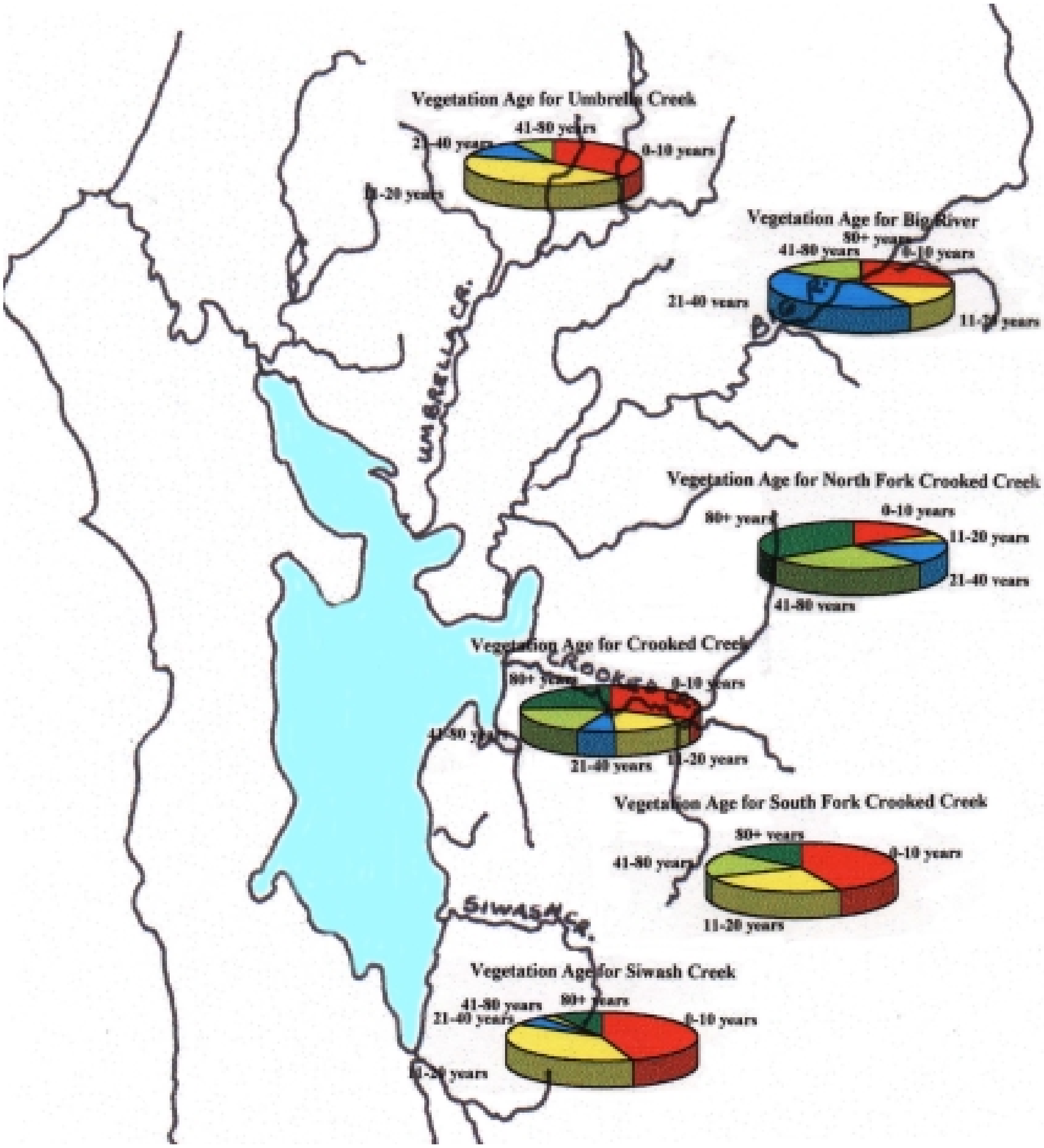
In the Ozette basin, summer water temperatures are warmer than State water quality standards in Umbrella Creek, Crooked Creek, and Big River (McHenry et al. 1996), and North Fork Crooked Creek is on the 303(d) list for water temperature. This results in a “poor” water quality rating for these streams. Summer water temperatures in Ozette River were also warmer than optimal, with maximum temperatures reaching 20^oC in late summer and early fall in the late 1970s (Bortleson and Dion 1979). In the mid-1990s, water temperatures in Ozette River reached as high as 23^oC on two dates in August, 1994, and equaled or exceeded 20^oC on all sampled days from July to September of that year (Meyer and Brinkman 1995), resulting in a “poor” rating. This rating might be surprising to some because Ozette River has significant land ownership under the Olympic National Park. The warm water temperatures in the Ozette River may be the result of a large, shallow outlet from the lake outlet coupled with dark water that absorbs heat more readily (Mike Haggerty, Makah Tribe, personal communication).

High flows result in turbid conditions within the tributaries that feed Lake Ozette, especially in Big River and Umbrella Creek (Bortleson and Dion 1979; Jacobs et al. 1996). The turbid conditions of the tributaries also affect the water quality of the lake. The December, 1999 storm event reduced the visibility of the lake to less than one foot for about 2-3 weeks (Mike Haggerty, Makah Tribe, personal communication). While the Ozette River has traditionally remained clear in storm events, Coal Creek has begun to contribute a sediment plume to the river, and is given a “poor” water quality rating for this reason (Jacobs et al. 1996).

Water Quantity in the Waatch, Sooes, and Ozette Basins

Extensive logging in the Ozette basin has resulted in an overall reduction of vegetation age. The widespread removal of trees is thought to increase storm run-off, thereby increasing peak flows in streams and increasing mortality of incubating salmon eggs (Rothacher 1963, 1965; Kovner 1957). Using age of vegetation 20 years old or younger as a measure of potential impact, the watersheds most impacted are Umbrella Creek (80% of watershed with less than 20 year vegetation), Siwash Creek (83%), and South Fork Crooked Creek (69%), resulting in “poor” water quantity ratings. Crooked Creek (49%) and Big River (41%) have been less impacted, and Crooked Creek has a significant amount of vegetation that is older than 80 years old. Most of the vegetation in North Fork Crooked Creek is 41 years or older (excellent hydrologic maturity). The percent age-class vegetation is detailed in Figure 1.

Figure 1. Hydrologic maturity in the Ozette Basin.



From the late 1970s through the late 1980s, peak flows exceeded the upper range of preferred sockeye flows by 9, 6, and 4 fold in Ozette River, Big River, and Umbrella Creek, respectively (Blum 1988). This time period followed extensive logging.

Potential flow impact data could not be found for the Waatch and Sooes basins, and this is a data need.

Lake Habitat in the Ozette Basin

Lake Ozette is drained to the Pacific Ocean by Ozette River, and the elevation drop from the outlet to the mouth is only 9 meters. Lake Ozette is used as a water source by local residents and the Olympic National Park Service (Dlugokenski et al. 1981). Water levels in the lake used to fluctuate by 12’ per year in the 1920s (Mike Haggerty, Makah Tribe, personal communication). Currently, the lake fluctuates about 8’ per year, with tributary flows dropping to less than 5 cfs (Mike Haggerty, Makah Tribe, personal communication; McHenry et al. 1996). It has been suggested that the change in the lake hydrograph is at least partially the result of the loss of LWD in the Ozette River, which drains the lake (Joel Freudenthal, Clallam County, personal communication).

The change in hydrology could contribute to the invasion of Reed canarygrass and sweetgale along the lake shoreline. The riparian adjacent to the lake is dominated by the native shrub, sweetgale (*Myrica gale*), and Reed canarygrass. Other vegetation includes horsetail, sedges, pondweed, smartweed, watershield, and grasses (Jacobs et al. 1996).

The spring-fed margins of Lake Ozette, such as Olson’s Landing, Allen’s Bay, and Umbrella Bay, have been the primary sockeye spawning sites, but recent high sedimentation impacts has severely degraded spawning habitat in Umbrella Bay (McHenry et al. 1996). Increased sediment is believed to be the cause of degraded lakeshore spawning habitat, particularly in the north (Jacobs et al. 1996), and this is a major habitat problem in the lake. The sediment problem along with invasive plants on the beach, results in a “poor” lake habitat rating. The cause of the sedimentation is not yet known. It could be due to effects from timber harvest and roads; a side-effect from a changed lake hydrology related to wood loss in the Ozette River; to reduced levels of spawners to clean the gravel, or a combination of these reasons.

After emergence from the gravel, sockeye fry depend upon zooplankton as a major food source (Foerster 1925; Ricker 1938), and generally high zooplankton densities result in greater smolt production (Brannon 1972). In the late 1970s, zooplanton levels in Lake Ozette were measured and compared to sockeye smolt production from lakes in Canada, Russia, and Alaska. Lake Ozette zooplankton levels fell in the middle range when compared to other lakes. The lakes with lower zooplankton densities were producing much larger numbers of sockeye smolts, which indicates that zooplankton levels in Lake Ozette were not limiting at the time of this study (Dlugokenski et al. 1981).

Both water temperature and dissolved oxygen levels in Lake Ozette are adequate for salmon use. In 1976, dissolved oxygen measurements within Lake Ozette exceeded 8 ml/L at all depths, and water temperatures were within an acceptable range for salmon (Bortleson and Dion 1979; Meyer and Brinkman 1995).

Biological Processes in the Ozette Basin

Nutrient cycling is assessed for this report by the attainment of escapement goals. Because none of the salmon and steelhead species in the Ozette basin appears to be at healthy levels, the Ozette basin rated “poor” for biological processes.

Other biological processes have been considered. Prickly sculpin, northern squawfish (northern pike minnow) and cutthroat trout within Ozette Lake have been implicated as a possible cause for declining sockeye populations. All species are present in the lake and are known predators on juvenile sockeye and other salmon (Dlugokenski et al. 1981), but all are thought to be native to the lake and no known habitat changes have occurred to promote opportunistic species. The last point is important because this report focuses on species interactions only due to a change in habitat conditions.

Kokanee, yellow perch (introduced), and peamouth are also present in the lake and are known competitors with sockeye salmon juveniles. The authors did not think that potential interactions between sockeye and yellow perch, peamouth, and squawfish were significant because of spatial separation. Largemouth bass have also been introduced to the lake, but not enough information is available to assess impact on salmon production (Jacobs et al. 1996). At this time, no specific impacts have been described that would be due to habitat changes that promote opportunistic species proliferation.

In another study, Daphnia levels were measured and compared to the numbers kokanee and juvenile sockeye (Beauchamp et al. 1995). These authors surmised that the combined consumption of Daphnia by all year classes of kokanee and all juvenile sockeye accounts for less than 1% of the standing biomass of Daphnia in Lake Ozette. This indicates that food competition between kokanee and juvenile sockeye is likely not a limiting factor.

Harbor seals and river otters are common within Ozette River and Lake Ozette, overlapping spatially and temporally with sockeye spawners. Predation by both seals and otters was observed in 1998 and 1999, but predation losses have not been quantified (Mike Haggerty, Makah Tribe, personal communication). NMFS (1995) has stated that impacts of marine mammal predation on salmonids do not appear to be a major problem unless all of the following conditions are met: high local abundance of marine mammals during salmon migrations; restricted passage of salmon; and depressed salmon stocks.

Habitat Limiting Factors in the Quillayute Basin

<u>Loss of Access in the Quillayute Basin</u>

Introduction

There are no significant natural barriers to salmonids in the Dickey sub-basin due the low gradient morphology (Rayonier 1998, Module E). The highly productive nature of the Dickey sub-basin for coho salmon, elevates the importance of culverts and other blockages that would reduce this productivity. While winter rearing habitat is abundant, spawning habitat is limited, and blockages to spawning habitat should have a high restoration priority. Also, warm water temperatures reduce the quantity and quality of summer rearing habitat, and blockages to good summer rearing habitat should also have a high restoration priority. Despite the greater need for unblocked habitat in the Dickey sub-basin, nearly 40 culverts have been documented in the sub-basin, resulting in a "poor" access rating. Many are concentrated in the Ponds Creek watershed (Rayonier 1998, Module F). The culvert inventories covered about 80% of the streams, and the estimate of culverts is considered conservative. The locations of the culverts are shown in Map 4 (all maps are in a separate electronic file), and are listed below. Some of these might have been recently replaced, and field verification for any of the passage problems is recommended prior to restoration planning.

Passage problems for the remainder of the Quillayute basin are also listed below and shown on Map 4. Additional watersheds that rated "poor" for access are Tassel Creek (Soleduck) and Gunderson Creek (Soleduck). Culvert surveys are greatly needed in the Bogachiel sub-basin, and this list includes only a small number of blockage problems that likely exist in that region.

Prioritization was based upon the following factors: the amount of salmon or steelhead habitat blocked; the number of salmon and steelhead species blocked; the stream gradient (lower gradient assumes greater productivity); and Technical Advisory Group judgement of the relative importance.

Blockages in the Quillayute Basin in Priority Order

1) A culvert located at RM 0.9 in a West Fork Dickey tributary (20.0142) blocks 2.5 miles of known coho habitat and 1.9 miles of known steelhead habitat (Rayonier 1998).

2) A culvert located at RM 1 in a Gunderson Creek tributary (20.0188) blocks 3.3 miles of coho habitat and 1 mile of steelhead habitat (Rayonier 1998).

3) A culvert located at RM 2.6 in a Skunk Creek tributary (20.0121x) is blocking 2.9 miles of known coho habitat and 0.7 miles of known steelhead habitat (Rayonier 1998).

4) A culvert at RM 1.2 in a Tassel Creek tributary (20.0305) blocks 1.6 miles of coho and steelhead habitat (Theresa Powell).

5) A culvert at RM 0.3 in a West Fork Dickey tributary (20.0138) blocks 2.1 miles of coho habitat (Rayonier 1998).

6) A culvert at RM 1.37 on Tassel Creek (20.0305 in the Soleduck watershed) blocks 2.4 miles of habitat used by coho salmon and steelhead trout (SSHEAR 1998).

7) A culvert at RM 1.6 blocks in a Ponds Creek tributary (20.0155) blocks 0.7 miles of coho, chum, and steelhead habitat (Rayonier 1998).

8) A culvert at RM 0.5 in an East Fork Gunderson tributary (20.0304a) blocks 2 miles of coho habitat (Theresa Powell). This culvert is associated with Road D 2000.

9) A culvert at RM 0.1 in a Middle Fork Dickey tributary (20.0145x), blocks 1.6 miles of presumed coho habitat (Rayonier 1998).

10) A culvert at RM 0.1 in an East Fork Gunderson tributary (20.0304ax) blocks 1.5 miles of coho habitat (Theresa Powell).

11) A culvert at RM 1.5 in an East Fork Dickey tributary (20.0114ax) blocks 1.4 miles of coho habitat (Rayonier 1998).

12) A culvert at RM 0.9 in a West Fork Dickey tributary (20.0158) blocks 1.1 mile of coho habitat and 0.5 miles of steelhead habitat (Rayonier 1998).

13) A culvert at RM 0.1 in a Swanson Creek tributary (20.0312x) blocks 1.1 miles of coho habitat (Theresa Powell).

14) A culvert located at RM 1.4 in an East Fork Gunderson tributary (20.0304ax) blocks 1.1 miles of coho habitat (Theresa Powell). Due to its upstream location, this culvert should be addressed after culvert #14 has been replaced.

15) A culvert located at RM 0.5 in a Tassel Creek tributary (20.0307x) blocks 0.9 miles of coho habitat (Theresa Powell).

16) A culvert located at RM 0.5 in a Bogachiel tributary (20.0162x) blocks 0.9 miles of presumed coho habitat (DOT 1999).

17) A culvert located at RM 0.3 in a Bogachiel tributary (20.0162x) blocks 0.9 miles of presumed coho habitat (DOT 1999).

18) A culvert at RM 0.9 in Little Thunder Creek (20.0155) blocks 0.8 miles of coho habitat (SSHEAR 1998). This should be addressed prior to the culvert listed below.

19) A culvert at RM 1.6 in Little Thunder Creek (20.0155) blocks 1.5 miles of coho habitat (SSHEAR 1998).

20) A culvert at RM 0.0 in a West Fork Gunderson Creek tributary (20.0304x) blocks 0.7 miles of coho habitat (Theresa Powell).

21) A culvert at RM 0.0 in an East Fork Gunderson Creek tributary (20.0304ax) blocks 0.7 miles of coho habitat (Theresa Powell).

22) A culvert located at RM 0.1 in a North Fork Calawah tributary (20.0183x) blocks 0.7 miles of potential juvenile coho habitat (U.S. Forest Service 1996).

23) A culvert located at RM 0.4 in a Soleduck tributary (20.0335) blocks 0.6 miles of presumed coho habitat (Theresa Powell).

24) A culvert located at RM 0.2 in a North Fork Calawah tributary (20.0184) blocks 0.6 miles of juvenile coho habitat (U.S. Forest Service 1996).

25) A culvert at RM 0.2 in a Middle Fork Dickey tributary (20.0145x), blocks 0.5 miles of presumed coho habitat (Rayonier 1998).

26) A culvert at RM 0.2 in a West Fork Dickey tributary (20.0097x) blocks 0.5 miles of presumed coho habitat (Rayonier 1998).

27) A culvert at RM 0.5 in an East Fork Dickey tributary (20.0122x) blocks 0.5 miles of presumed coho habitat (Rayonier 1998).

28) A culvert from Road B 2130 at RM 0.4 in a Shuwah tributary (20.0307x) blocks 0.5 miles of known coho habitat (Theresa Powell).

29) A culvert at RM 0.5 in a Bockman Creek tributary (20.0302x) blocks 0.5 miles of coho habitat (Theresa Powell).

30) A culvert at RM 0.2 in a North Fork Calawah tributary (20.0175x) blocks 0.3 miles of high priority coho habitat. This habitat is near the mainstem drying reach, and could provide important summer rearing refuge habitat.

31) A culvert at RM 0.7 in a Haehule Creek tributary (20.0160x) blocks 0.4 miles of coho habitat (Rayonier 1998).

32) A culvert at RM 0.6 in a West Fork Dickey tributary (20.0097x) blocks 0.4 miles of presumed coho habitat (Rayonier 1998).

33) A culvert at RM 0.1 in a West Fork Dickey tributary (20.0097x) blocks 0.4 miles of presumed coho habitat (Rayonier 1998).

34) A culvert at RM 0.1 in a Thunder Creek tributary (20.0115x) blocks 0.4 miles of coho habitat (Rayonier 1998).

35) A culvert at RM 0.1 in an East Fork Dickey tributary (20.0110x) blocks 0.4 miles of coho habitat (Rayonier 1998).

36) A culvert located at RM 0.9 in a Soleduck tributary (20.0336) blocks 0.6 miles of coho habitat (Theresa Powell).

37) A culvert at RM 0.2 in a Ponds Creek tributary (20.0153x) blocks 0.3 miles of coho habitat (Rayonier 1998).

38) A culvert at RM 0.2 in a Ponds Creek tributary (20.0153x) blocks 0.3 miles of coho habitat (Rayonier 1998).

39) A culvert at RM 0.2 in a Ponds Creek tributary (20.0153x) blocks 0.3 miles of presumed coho habitat (Rayonier 1998).

40) A culvert at RM 0.1 in a West Fork Dickey tributary (20.0097x) blocks 0.3 miles of presumed coho habitat (Rayonier 1998).

41) A culvert at RM 0.4 in a West Fork Dickey tributary (20.0097x) blocks 0.3 miles of coho habitat (Rayonier 1998).

42) A culvert at RM 0.1 in a Lake Creek tributary (20.0313x)m blocks 0.3miles of coho habitat (Theresa Powell).

43) A culvert at RM 0.7 in a Lake Creek tributary (20.0316)m blocks 0.3miles of coho habitat (Theresa Powell).

44) A culvert at RM 0.2 in a Bear Creek tributary (20.0330x) blocks 0.3 miles of coho habitat (Theresa Powell).

45) A culvert located at RM 0.4 in a Bogachiel tributary (20.0162x) is a 15% blockage of 0.3 miles of presumed coho habitat (DOT 1999).

46) A culvert at RM 1 in a Dowans Creek tributary (20.0248x) is an 20% blockage of 0.3 miles of coho habitat (DOT 1999).

47) A culvert at RM 0.5 in a Beaver Creek tributary (20.0324x) blocks 0.15 known and 0.1 mile of presumed coho habitat (Theresa Powell).

48) A culvert at RM 0.3 in a Middle Fork Dickey tributary (20.0145x), blocks 0.2 miles of presumed coho habitat (Rayonier 1998).

49) A culvert at RM 0.6 in a Middle Fork Dickey tributary (20.0145x), blocks 0.4 miles of presumed coho habitat (Rayonier 1998).

50) A culvert at RM 0.2 in a Gunderson Creek tributary (20.0118) blocks 0.2 miles of coho habitat (Theresa Powell).

51) A culvert at RM 0.1 in a Gunderson Creek tributary (20.0118) blocks 0.2 miles of presumed coho habitat (Theresa Powell).

52) A culvert at RM 0.1 in a Gunderson Creek tributary (20.0118) blocks 0.2 miles of presumed coho habitat (Theresa Powell).

53) A culvert at RM 0.5 in a Beaver Creek tributary (20.0324x) blocks 0.2 miles of coho habitat (Theresa Powell).

54) A culvert at RM 0.2 in a Skunk Creek tributary (20.0121x) blocks 0.2 miles of presumed coho habitat (Rayonier 1998).

55) A culvert at RM 0.2 in an East Fork Dickey tributary (20.0110x) blocks 0.2 miles of presumed coho habitat (Rayonier 1998).

56) A culvert at RM 0.1 in a West Fork Gunderson tributary (20.0304x) blocks 0.2 miles of coho habitat (Theresa Powell).

57) A culvert at RM 0.2 in Forgotten Marsh (20.0237x) blocks 0.2 miles of presumed coho habitat (DOT 1999).

58) A culvert at RM 0.0 in a West Fork Gunderson tributary (20.0304x) blocks 0.1 miles of coho habitat (Theresa Powell).

59) A culvert at RM 0.7 in a Soleduck tributary (20.0096x) blocks 0.1 miles of coho habitat (Theresa Powell).

60) A culvert at RM 0.3 in a Beaver Creek tributary (20.0324x) blocks 0.1 miles of potential coho habitat (Theresa Powell).

61) A culvert at RM 0.1 in a Haehule Creek tributary (20.0160x) blocks 0.1 miles of presumed coho habitat (Rayonier 1998).

62) A culvert at RM 0.1 in a Haehule Creek tributary (20.0160x) blocks 0.1 miles of presumed coho habitat (Rayonier 1998).

63) A culvert at RM 0.4 in a Dickey Lake tributary (20.0097x) blocks 0.1 miles of coho habitat (Rayonier 1998).

64) A culvert at RM 0.1 in a Middle Fork Dickey tributary (20.0145x), blocks 0.1 miles of coho habitat (Rayonier 1998).

65) A culvert at RM 0.1 in a Middle Fork Dickey tributary (20.0145x), blocks 0.1 miles of coho habitat (Rayonier 1998).

66) A culvert at RM 1.1 in a West Fork Dickey tributary (20.0097x) blocks 0.1 miles of coho habitat (Rayonier 1998).

67) A culvert at RM 0.0 in a West Fork Dickey tributary (20.0097x) blocks 0.1 miles of presumed coho habitat (Rayonier 1998).

68) A culvert at RM 0.1 in a West Fork Dickey tributary (20.0097x) blocks <0.1 mile of presumed coho habitat (Rayonier 1998).

69) A culvert at RM 0.1 in a Gunderson tributary (20.0304x) blocks <0.1 miles of coho habitat (Theresa Powell).

70) A culvert associated with Highway 101 at RM 0.2 in a Hemp Hill Creek tributary (20.0249x) blocks an unknown amount of coho habitat (DOT 1999).

71) A culvert on stream 20.0183A (Calawah Watershed) blocks access to juvenile salmonid in the winter (Rayonier 1996).

72) A culvert on stream 20.0184 (Calawah Watershed) blocks access to juvenile salmonid in the winter (Rayonier 1996).

73) Hatchery racks block an unknown amount of habitat. Three exist on the Calawah River, one on the Bogachiel River, and two on the Soleduck River. It has been suggested that overwintering ponds constructed downstream of these racks would aid natural coho production (Dick Goin, personal communication).

<u>Floodplain Impacts in the Quillayute Basin</u>

Riparian Road Impacts

The most common floodplain impact in the Quillayute basin is the presence of riparian roads. Some of these roads closely parallel the streams, acting as dikes, disconnecting potential off-channel habitat, and increasing sediment inputs into the stream. The most heavily impacted streams are listed in Table 4. Using the rating criteria outlined in the Assessment Chapter, several streams rated "poor" for floodplain impact, including Colby Creek, Coal Creek Tributary 20.0104, Shuwah Creek, Bear Creek, Hyas Creek, Cool Creek, Devils Creek, and Hemp Hill Creek. The mainstems of the Soleduck River, Bogachiel River, and North Fork Calawah River had extensive impacts as measured in total impact length, but when compared to the length used by salmon and steelhead, the impacts for these mainstems fell into the "fair" category. Still, these mainstem impacts as well as the impact in the South Fork Calawah mainstem should be a concern, especially considering the greater number of species using that habitat.

Table 4. Riparian roads in the Quillayute Basin.

Stream	Range (RM) Impacted, name of road	Species Impacted	Habitat Rating
Dickey Watershed:			
Coal Creek	3.7-4.6	Coho, steelhead, fall chinook	Fair
Coal Cr. Tributary 0104	0-0.7	Coho, steelhead	Poor
Colby Creek	0-2	Coho, steelhead, fall chinook	Poor
Soleduck Watershed:			
Soleduck River	50.9-67 (Forest Service Rd) and miscellaneous locations between 22-49 from HWY 101.	Coho, steelhead, summer chinook.	Fair
South Fork Soleduck	2.1-4.3 (Forest Service Rd. 303)	Coho, steelhead	Fair
North Fork Soleduck	4.3-8	Coho, steelhead	Fair
Shuwah Creek	0.9-7	Coho, steelhead, fall chinook	Poor
Bear Creek	3.6-9 (Forest Service Rd. 30)	Coho, steelhead, fall chinook, summer chinook	Poor
Calawah Watershed:			
North Fork Calawah	2.5-10 (Forest	Coho, steelhead, fall chinook, summer chinook,	Fair

	Service Rd. 2993)	chum	
South Fork Calawah	11.2-11.6, 13.1-15.2 (Forest Service Rd. 300)	Coho, steelhead, fall chinook, summer chinook, spring chinook, sockeye	Fair
Cool Creek (NF)	0-1.6	Coho, steelhead, fall chinook	Poor
Devils Creek (NF)	0.1-0.9 (Schutz Pass)	Coho, steelhead	Poor
Sitkum River	1-2.7 (Forest Service Rd. 300)	Coho, steelhead, fall chinook, summer chinook, sockeye	Fair
Hyas Creek	0.1-3.6	Coho, steelhead	Poor
Bogachiel Watershed:			
Bogachiel River	19.4-33.8	Coho, steelhead, fall chinook, summer chinook, spring chinook	Fair
Mill Creek	Most sections between 2.5-4	Coho , steelhead	Fair
Elk Creek	1-3.2	Coho, steelhead, fall chinook	Fair
Hemp Hill Cr.	0-1	Coho, steelhead	Poor

Other Floodplain Issues in the Quillayute Basin

Lateral habitat and wetlands are especially important for continued good coho salmon production in the Dickey sub-basin (Figure 2), and adequate riparian vegetation surrounding the wetlands is important for temperature and ecological function. Wetland channels with marsh vegetation are common throughout the Squaw, Ponds, and Thunder Creek watersheds (Rayonier 1998, Module D). These areas have wet soils that result in naturally unshaded conditions, but in Thunder Creek, partial shade historically occurred from nearby areas because the wetlands are generally less than 100’ wide. Past logging practices did not leave buffers in these areas. Currently, young conifers exist near the

Thunder Creek wetlands, and will provide future shade, although current conditions are less than desirable.

In the Soleduck watershed, Gunderson Creek, Shuwah Creek, Lake Creek, Beaver Creek, and upper Bear Creek have high value off-channel and wetland habitat important for rearing salmonids (U.S. Forest Service 1995). These areas should be maintained for salmon productivity.

Figure 2. Still water off-channel habitat in the Dickey sub-basin.

The entire Soleduck watershed has only about 3% wetlands, and impacts are reducing these already limited habitats (U.S. Forest Service 1995). Fill for road construction has directly displaced at least 4 acres of wetlands in the region. In addition, many wetlands have vegetation changes due to logging, agriculture, and development. Examples include the North Fork Bear Creek and east side of Lake Pleasant, where riparian areas have been converted to deciduous trees. There is high concern over the loss of off-channel habitat in the South Fork Soleduck River, and lower Bear Creek. Moderate concern has been documented for Camp and Kugel Creek off-channel habitat loss as well (U.S. Forest Service 1995). All of these streams are rated “poor” for floodplain impacts.

Historically, the North Fork Calawah had a wide floodplain, which has been narrowed due to channel incision (Dick Goin, personal communication). The likely cause of the incision is a combination of excessive sedimentation and a lack of LWD (see Streambed Sediment section). The North Fork Calawah River has been rated “poor” for floodplain condition because of the channel incision.

Channel incision has been noted in the lower Bogachiel sub-basin, and is probably caused by a lack of LWD and increased sediment transport. The incision has exposed unstable clay layers that release fine sediments into the streams, which has degraded sediment quality. This has been especially noticed in May Creek and in the lower mainstem Bogachiel River (Dick Goin, personal communication; Jill Silver, Hoh Tribe, personal communication). The channel incision has resulted in a "poor" rating for floodplain condition in the lower Bogachiel mainstem.

<u>Streambed Sediment Conditions in the Quillayute Basin</u>

Dickey River and Tributaries

The Dickey watershed is a low gradient system with three major rivers (West Dickey, East Dickey, Middle Dickey), two large creeks (Thunder and Skunk Creeks), and a large lake (Dickey Lake). All of these receive water from numerous small tributaries, which seldom have natural barriers because of the low gradient terrain (Rayonier 1998, Module F). The West Dickey begins at the outlet of the lake, and consists mostly of a deep glide with few isolated riffles and gravel bars (Rayonier 1998). Spawning habitat is limited because Dickey Lake traps sediments from the headwaters, preventing the transport of gravels. The two largest spawning areas within the West Dickey are supplied with gravel from other streams. They are located just downstream of the confluence with the Middle Dickey and below the confluence with Squaw Creek. Fine sediments are high (25.5%) in the West Dickey, resulting in poor spawning habitat quality in addition to very limited spawning quantity (Rayonier 1998, Module F).

The East and Middle Dickey Rivers drain the hills that separate the Hoko Watershed from the Dickey. They have a greater range of gradient and habitat features than the West Dickey, with adequate pool-riffle habitat (Rayonier 1998). The Middle Dickey provides important spawning habitat for the West Dickey system, yet the most abundant spawning habitat in the Dickey Watershed is located in the East Dickey River (Rayonier 1998, Module F). The primary source of spawning gravel comes from stream bank erosion (Rayonier 1998).

Throughout the Dickey Watershed, fine sediment levels were generally high with extensive substrate embeddedness (Rayonier 1998, Module F). Out of 10 sites sampled, 8 were rated as "poor" (>17%), 2 were "fair" (11-17%), and none were "good". "Poor" sites were located in Stampede Creek, Skunk Creek, stream 20.0141, East Dickey River, Fluharty Creek, Middle Dickey River, West Dickey River, and stream 20.0129 (Rayonier 1998, Module F). The high percentage of fines results in a loss of interstitial spaces favored by steelhead trout juveniles in the winter.

One major source of fine sediments is from roads, especially the mainline and secondary roads: 2000, 5000, 5200, 9000, which deliver more than 80% of the road input sediment (Rayonier 1998, Module A). Road sedimentation is worsened by the high precipitation levels and the local road surfacing materials.

Road erosion sediment delivery is highest in the Middle Dickey, No-name Slough 1, Thunder Creek, Squaw Creek, East Dickey mainstem headwaters, Dickey Lake, and Gunderson Creek West (Rayonier 1998, Module A). Moderate road erosion inputs occur in No-name Slough 2, No-name Slough 3. Inputs are low in the East Dickey middle mainstem, Ponds Creek, Skunk Creek, Stampede Creek, and the West Dickey lower mainstem.

Sedimentation is also a problem in the numerous small tributaries. Many of the small tributaries are incised with collapsing stream banks (Dick Goin, personal communication). In areas where debris flows occurred, there is a lack of LWD. Large stumps in the riparian zone used to contribute to bank stability, but these have been rotting away, contributing to the erosion problem.

Mass wasting is rare in the Dickey watershed, with only 12 mass wasting sites identified, and only 2 of those deliver sediment to streams (Rayonier 1998, Module A). Hillslope surface erosion contributes more sediment than mass wasting. Of the 35 hillslope erosion sites that were found to deliver sediment to streams, 10 were caused by historic logging practices that no longer occur today, 4 were due to side-cast technology roads, and 21 attributed to clearcuts (Rayonier 1998, Module A), resulting in "poor" sediment ratings for these streams. Inactive roads were estimated to contribute small levels of fines due to the quick revegetation that occurs in the area.

Moderate channel migration occurred in pool-riffle sections of the West Dickey, and until 1999, channels appeared to be fairly stable in the Dickey system (Rayonier 1998, Module F). Channel changes have been noticed in the East Fork Dickey after the December, 1999 flood (Dick Goin, personal communication). Severe aggradation has occurred in the mainstem Dickey River, East Fork Dickey River, and in Skunk Creek. Historically Skunk Creek was deep and sinuous, but is now braided and highly aggraded.

Using criteria from Watershed Analysis, LWD levels were mostly "good" (19/45 sites), with 14 sites rated "fair" and 12 sites rated "poor" (Map 5a) (Rayonier 1998, Module F). The West Dickey and Middle Dickey have better levels of LWD than the East Dickey. A long stretch of the lower East Dickey mainstem rated "poor" for LWD because of recent floods (Dec. 1999) which removed much of the existing wood (Dick Goin, personal communication). The low energy of the West Dickey results in low wood transport; once wood is recruited, it stays for a long time (Rayonier 1998, Module D). However it is important to note that our criteria do not take into consideration the change from historic conditions and are not tailored for low gradient, historically "wood-rich" streams, such as the Dickey watershed. In particular, the West Dickey used to be nearly solid with logjams prior to timber harvest activities (Dick Goin, personal communication). While these areas might rate "good" or "fair" with our criteria, they are still degraded compared to historic conditions.

Soleduck River and Tributaries

The Soleduck drainage is predominately confined, bedrock-boulder controlled, which limits its ability to store sediment and LWD, particularly in the upper reaches (Bishop and Morgan 1996; U.S. Forest Service 1995). Sedimentation is worsened by steep slopes and the high levels of precipitation, which result in faster rock weathering and vegetative growth. Wildfire and intense storms with high winds contribute to high natural rates of sedimentation.

Mass wasting contributes the greatest volume of sediment to the Soleduck River, and natural mass wasting levels are high, although overall, sedimentation in the Soleduck River is not as bad as in other nearby streams (U.S. Forest Service 1995). Human-caused increases in sedimentation are apparent when comparing watersheds located in the pristine Olympic National Park to those located elsewhere in the same watershed. Within the Soleduck sub-basin, 32% of the area has natural levels of sedimentation (Olympic National Park), and these reaches are located in the North Fork Soleduck, upper South Fork Soleduck, and Alckee Creek, where road densities are less than 1 mile road/sq. mi. watershed (U.S. Forest Service 1995). The North Fork Soleduck River and Alckee Creek are rated “good” for fine sediment levels. Fine sediment levels were also rated “good” for the mainstem Soleduck River, Tom Creek, and South Bear Creek. Because of their pristine condition, the North Fork Soleduck and Alckee streams are important habitat refuges for salmonid production.

Mass wasting is greatest in the South Fork Soleduck River, Camp Creek, Kugel Creek, and Tom Creek (U.S. Forest Service 1995). The South Fork Soleduck has the highest road density in the system (3.7 mi road/sq. mi. watershed), and road erosion exceeds the natural background rates by 199%. Road densities and road erosion are listed in Table 5 for other streams. Those that rated “poor” for both include South Fork Soleduck, Goodman Creek, Tom Creek, Camp Creek, and Bockman Creek.

In addition to road erosion, other sources of sediment include logging, wildfires (especially the Forks burn), and subsequent salvage after the Forks burn. The sediment sources in lower Camp, Kugel, Beaver, Bear, Bockman, Lake, Maxfield, and Gunderson Creeks have revegetated and appear to be in a recovery mode (U.S. Forest Service 1995). However sediment sources in the South Fork Goodman and Tom Creeks are expected to continue to contribute for the next few decades.

Table 5. Soleduck watershed road density and erosion rates (U.S. Forest Service 1995). Red="poor" rating, blue="fair", green="good" rating.

Stream	Road Density (miles of road/sq miles watershed)	Road Erosion rates (% over natural)
South Fork Soleduck	3.7	199%
Goodman Creek	3.2	148%
Mainstem Soleduck	2.9	140%
Gunderson Creek	2.8	124%
Tom Creek	4.0	117%
Camp Creek	3.1	113%
Beaver Creek	2.7	101%
Bockman Creek	3.1	100%
Lake Creek	3.2	98%
Kugel Creek	2.5	72%
Upper Bear Creek	1.7	62%
South Bear Creek	1.9	51%
Alckee Creek	0.9	56%
North Fork Soleduck	0	0%

Based upon the information above, sedimentation appears to be a major problem in the managed reaches of the Soleduck Watershed. Fine sediments are “poor” (greater than 17%) in the South Fork Soleduck River and in Camp, Kugel, Bear, Beaver, upper Lake, Bockman, Shuwah, and Gunderson Creeks. “Fair” levels of sediments are located in Goodman, Maxfield, lower Lake, and Tassel Creeks as well as in the lower mainstem Soleduck River (U.S. Forest Service 1995). “Good” levels of fine sediments were found in the North Fork Soleduck River and Alckee, Tom and South Bear Creeks.

There is the lack of LWD in numerous streams. Current levels of LWD are “good” in the Olympic National Park reaches such as the North Fork Soleduck and Alckee Creek, as well as in Goodman Creek (U.S. Forest Service 1995). Levels of LWD are “poor” in the mainstem South Fork Soleduck River and in several reaches of Tom, Bear, Lake, Beaver, Bockman, Tassel, Gunderson, Shuwah, and South Bear Creeks (Map 5a). "Fair" levels of LWD were noted in Camp Creek, Kugel Creek, and parts of Bear Creek (Roger Mosley, WDFW, personal communication). However, large rocks provide equivalent roughness to the streams in the Soleduck sub-basin, and many of the large boulders that provide this function have remained in place for long periods of time (Dick Goin, personal communication). Prior to any restoration activities involving LWD placement in the Soleduck, fieldwork should verify that it is needed, particularly considering the function of large rock.

The mainstem Soleduck River has been fairly stable in the last 50 years, based upon aerial photo and channel analysis (Bishop and Morgan 1996), but there has been some channel simplification noted after floods and streamcleaning events (U.S. Forest Service 1995). In tributaries such as Bear, Beaver, Lake and Shuwah Creeks, channel widening has been documented. Widening and aggradation has been noted in the mainstem between Shuwah and Tassel Creeks. Also, the mouth of the Soleduck has moved laterally in recent decades (U.S. Forest Service 1995). These areas rated "poor" for channel stability, with the exception of the Soleduck mainstem, which rated "fair".

Bogachiel Sub-Basin

Specific habitat survey data on sedimentation, streambed conditions, and LWD is lacking for the Bogachiel sub-basin. This information is a high priority data need. However, several members of the Limiting Factors TAG have noted some major problems. Sedimentation is a problem in the mainstem Bogachiel River downstream of the Olympic National Park. Aggradation is common and worsens further downstream (Dick Goin, personal communication). Collapsing banks are also a problem, particularly from the confluence with Hemp Hill Creek down to the mouth of the Bogachiel River (Figure 3). The streambank and channel instability has resulted in the need to move roads in the area upstream of Highway 101. These problems have resulted in "poor" ratings for sediment quantity and channel stability.

Another sedimentation issue in the Bogachiel sub-basin relates to channel incision caused by a lack of LWD and increased sediment transport. The incision has exposed unstable clay layers that release fine sediments into the streams. This has been especially noticed in May Creek and in the lower mainstem Bogachiel River (Dick Goin, personal communication; Jill Silver, Hoh Tribe, personal communication), resulting in a "poor" rating for sediment quality in these areas.

Large woody debris levels appear to be low in the mainstem Bogachiel below Highway 101, is better between the Highway 101 bridge up to about 2 miles further upstream. From that point, LWD condition is "poor" again for a large reach of the Bogachiel mainstem until just below the confluence with Hemp Hill Creek (Map 5a) (Dick Goin, personal communication). Levels of LWD are "good" within the Olympic National Park (John Meyer, ONP, personal communication). Levels of LWD in lower Maxfield and lower South Fork Maxfield Creeks are “fair” (Roger Lien, Quileute Tribe, personal communication). In Bear Creek, LWD is “fair” in the lower reaches and “good” in the upper reaches (Roger Lien, Quileute Tribe, personal communication).

Figure 3. Bank erosion on the mainstem Bogachiel River (Photo from Dick Goin).

Calawah River and Tributaries

Mass wasting is a major limiting factor throughout the Calawah Watershed, particularly in the Sitkum River, Hyas Creek, and the North Fork Calawah Rivers (Bishop and Morgan 1996; U.S. Forest Service 1996; Dick Goin, personal communication). Mass wasting in the North Fork Calawah Watershed is primarily triggered by road-related failures, including culvert failures (U.S. Forest Service 1996). The roads using side-cast technology are at the highest risk of creating more landslides. Surface erosion from roads is low in the North Fork Calawah Watershed, except in the headwaters, where the road density is high (4.4 miles road/sq.mi) (U.S. Forest Service 1996). The drainages with the greatest level of debris flows events/sq. mi. are listed below in Table 6.

Table 6. Debris flow events in the North Fork Calawah (U.S. Forest Service 1996).

Stream	Debris Flow Events/Sq. Mi.
Pistol Creek	8.01
Albion Creek	6.13
Upper mainstem	3.91
Mainstem headwaters	2.88
Eastern Cool Creek	2.29
Bonidu Creek	1.69
Stream 0184	1.62

Overall, sediment contribution to the North Fork Calawah River consists of 45% from harvest, 44% from roads, and 10% from natural sources (O'Connor and Cundy 1993). Albion Creek, Pistol Creek, Canyon Creek, and the mainstem headwaters contribute most of the sediment to the mainstem, and these streams are rated "poor" for sediment quantity (U.S. Forest Service). Sediment production in the North Fork Calawah has decreased since the early 1980s as the area healed from the Forks Fire and timber harvest stopped in the upper watershed. However, sediment production is not expected to continue to decrease without addition road restoration efforts (U.S. Forest Service 1996).

The quality of spawning gravel in the North Fork Calawah Watershed is "fair" based upon data in U.S. Forest Service (1996). Percent fine sediments ranged from 13.6-16.3% throughout the mainstem North Fork Calawah and in Western Cool Creek. Embeddedness is a problem in many areas of the North Fork Calawah, reducing the quality of spawning habitat (U.S. Forest Service 1996). This has been noted in the mainstem, Western Cool Creek, and Albion Creek.

Stability of spawning/incubation habitat is a major problem in the North Fork Calawah. Based upon limited scour monitoring, all scour monitors were either scoured completely out or were covered over (U.S. Forest Service 1996). Significant aggradation has occurred in the mainstem and Pistol and Albion Creeks, where the greatest channel changes also occurred, and were likely the result of large debris jams (U.S. Forest Service 1996). Lessor amounts of aggradation were noted in Western Cool and Devil's Creeks, resulting in "fair" channel stability ratings for these streams. "Poor" channel stability ratings are assigned to the North Fork Calawah River, Pistol Creek, and Albion Creek. The aggradation is likely the result of mass wasting events, and has led to a reduction in pool habitat and an increase in fine sediment. The current lack of LWD increases the rate of sediment transport, which worsen these problems (Map 5a).

The Calawah drainage is predominately confined, bedrock-boulder controlled, which limits its ability to store LWD. Most of the current LWD in the North Fork Calawah Watershed is alder. Counts were very low in the mainstem, but met target in assessed tributaries with the exception of Albion, which rated "fair" (Map 5a) (U.S. Forest Service 1996). Devil's Creek is important for anadromous salmon production and is not listed in Table 7 because data were collected under a different analysis. Based upon that data, Devil's Creek rated "good" for LWD levels (U.S. Forest Service 1996). For more information on the target standards, see the Assessment Chapter.

Table 7. North Fork Calawah LWD levels (U.S. Forest Service 1996).

Stream	LWD pieces/CW	Rating based upon standards	LWD key pieces/CW	Rating based upon standards
Lower mainstem (RM 0-7.8)	0.2	Poor	<0.1	Poor
Middle mainstem (RM 9-14)	0.1	Poor	0	Poor
Upper Mainstem (RM 15-16.5)	0.7	Poor	<0.1	Poor
Upper mainstem (RM 18-21)	2.8	Good	0.7	Good
Western Cool Creek	5.6-6.8	Good	3.2	Good
Eastern Cool Creek	3.3-3.4	Good	0.8-1.5	Good
Albion Creek	1.5-1.8	Fair	0.2-0.4	Fair
Pistol Creek	7.6-7.8	Good	1.8-1.9	Good

The mass wasting problem is extensive in the Sitkum and Hyas Watersheds, and “poor” ratings are given for sediment quantity in these streams. Most of the landslides are associated with roads (49%) with 36% of the failures due to natural causes and 15% due to timber harvest (U.S. Forest Service 1998). Many of the road-related failures are from roads built in the 1950s. Road fill is the greatest cause of landslides in the lower Sitkum River, Rainbow Creek, the North Fork Sitkum River, and Hyas Creek. Most landslides are located within the Hyas and upper Sitkum areas where the greatest amount of timber harvest and road building has occurred (U.S. Forest Service 1998). Numerous slides exist in the lower Sitkum as well (Figure 4) (Dick Goin, personal communication). Road densities within the Sitkum are high, resulting in a “poor” rating.

Landslides are also a problem in the South Fork Calawah Watershed. While most have natural causes (13/33), road fill is associated with 12 out of 33 slides and timber harvest is the cause of 8 failures (U.S. Forest Service 1998). Because of the excessive sedimentation, these streams have been rated “poor” for sediment quantity.

Road building and timber harvest have increased the rate and volume of mass wasting activity compared to historic levels (U.S. Forest Service 1998). This has kept the South Fork Calawah and Sitkum Rivers in a state of fluctuation. Historically, larger storms would have been required to trigger landslides with more recovery time between the natural sediment inputs. The increased mass wasting has decreased recovery time, and has led to a less stable watershed. Because of this, channel stability is rated “poor”.

While overall the road density is “good” at 1.4 mi/square mile watershed, the overall rating is influenced by the lack of roads in the Olympic National Park (U.S. Forest Service 1998). When road density is examined in smaller watershed units, “poor” ratings are found for areas of the middle Sitkum River (density=3.1 mi/sq.mi), the lower Sitkum River (3.6 mi/sq. mi), Rainbow Creek (3.1 mi/sq. mi), and the mainstem South Fork Calawah (3.5 mi/sq. mi) (U.S. Forest Service 1998). The excessive sedimentation has contributed to dewatered sections of Hyas Creek and the Sitkum River (see Water Quantity section).

Figure 4. Road-triggered landslide in the lower Sitkum River (photo from Dick Goin).

Key pieces of LWD are currently "poor" in Hyas Creek, Rainbow Creek, the Sitkum River, and the South Fork Calawah River (U.S. Forest Service 1998).   Smaller wood is also at "poor" levels in Hyas Creek and limited sections of the Sitkum and South Fork Calawah Rivers (Map 5a) (U.S. Forest Service 1998). Other sections of the Sitkum and South Fork Calawah Rivers rated "good" for the smaller, functional pieces of LWD. One reason that Hyas Creek is "poor" in both types of LWD is the Great Forks Fire of 1951 and the subsequent salvage.

Riparian Conditions in the Quillayute Basin

Dickey River and Tributaries

Historically the Dickey Watershed riparian area was dominated by Sitka Spruce and western hemlock with lesser quantities of red cedar and red alder (Rayonier 1998, Module D).   Extensive logging occurred from the 1940s to the early 1980s, leaving few or no riparian buffers. This has resulted in increased hardwoods, compared to average historic conditions. However, using our rating system (see Assessment Chapter), most riparian segments in the Dickey sub-basin rated "good" or "fair" (Map 6b). The most significant "poor" reaches were documented in Gunderson Creek, the lower East Fork Dickey River, no-name slough #2, Skunk Creek, Stampede Creek, Ponds Creek, and the upper Middle Dickey watersheds.

Windthrow is a major disturbance of the Dickey riparian (Figure 5). While some riparian windthrow is natural, it is worsened with the removal of dense forest stands that are perpendicular to winds coming from the southwest, south, and southeast (Bretherton et al. in prep.). The average windthrow is 30% (of total number of trees left in the riparian zone) in the Dickey Watershed, with greater levels (48%) of windthrow in the West Dickey. Western hemlock comprised the majority of windthrow, while Sitka Spruce was much more windfirm (Bretherton et al. in prep.). Smaller streams (less than 50' in width) were more susceptible (37-40% windthrow levels) than larger streams (4% windthrow).

Figure 5. An example of windthrow in the Dickey Watershed (picture by Theresa Powell)

Near-term LWD recruitment potential is low in the East Dickey lower and middle mainstem, Thunder Creek, No-name Slough 1, lower Gunderson Creek, No-name Slough 3, and the middle reaches of the Middle Dickey (Rayonier 1998, Module D).

In 1998, pool habitat was rated mostly "good" (31/53 sites), with 13 sites rated "fair" and 8 sites rated "poor" (Rayonier 1998, Module F). "Poor" percent area pool habitat was located in two tributaries to Thunder Creek, the West Fork Dickey River near Wentworth Lake, and several segments in the East Fork Dickey River. However, the December, 1999 flood resulted in significant pool filling. Quality pools are now uncommon in the Dickey sub-basin, and historically, there were numerous very large, deep pools in this sub-basin (Dick Goin, personal communication). This pool habitat is important for thermal refuges from high summer water temperatures, and contributes to the important coho salmon rearing habitat in the Dickey River (see Water Quality section).

Soleduck River and Tributaries

Historically, the riparian zone in the Soleduck Watershed contained more tree species diversity and late successive vegetation than current conditions (U.S. Forest Service 1995). The historic riparian was dominated by Sitka spruce and western hemlock. Now the riparian is dominated by red alder, western hemlock and Douglas fir. Areas rated as "poor" (predominately hardwood or open) include: lower Beaver, lower Camp, lower Tassel, lower Gunderson Creeks and sections of the mainstem Soleduck River, Bear Creek, Bockman Creek, and Shuwah Creek (Map 6b) (U.S. Forest Service 1995).

Near-term recruitment potential of LWD is especially poor in Kugel, Lake, Gunderson, Tom Creeks, and to a lessor extent, Bear Creek (U.S. Forest Service 1995). Bear Creek is noted as special habitat because it supports the highest number of spawners/mile in the Soleduck Watershed.

Pool habitat has been rated "poor" in lower Bear, Shuwah, Camp, and Kugel Creeks, and rated "good" in upper Bear, Lake, Tassel, Alckee, Goodman, and Tom Creeks as well as in the North Fork Soleduck and mainstem Soleduck River (U.S. Forest Service 1995). "Fair" pool habitat was noted in Bockman and South Bear Creeks as well as in the South Fork Soleduck River. Pools in Beaver Creek have been slowly filling, resulting in a "poor" rating (Dick Goin, personal communication).

Bogachiel Watershed

Specific habitat survey data on riparian conditions is lacking for the Bogachiel watershed. This information is a high priority data need. However, several members of the Limiting Factors TAG have noted some major problems. In the mainstem Bogachiel River, the riparian along the lowest reaches of the Bogachiel mainstem were rated "poor" while the middle reaches were rated "fair" (Roger Lien, Quileute Tribe, personal communication). The mainstem in the Park was rated "good", due to the old growth riparian (Map 6b). The riparian was estimated as "fair" in the lower reaches of Maxfield, South Fork Maxfield, and Bear Creeks, while the upper reaches were estimated as "good" in those streams (Roger Lien, Quileute Tribe, personal communication).

Calawah River and Tributaries

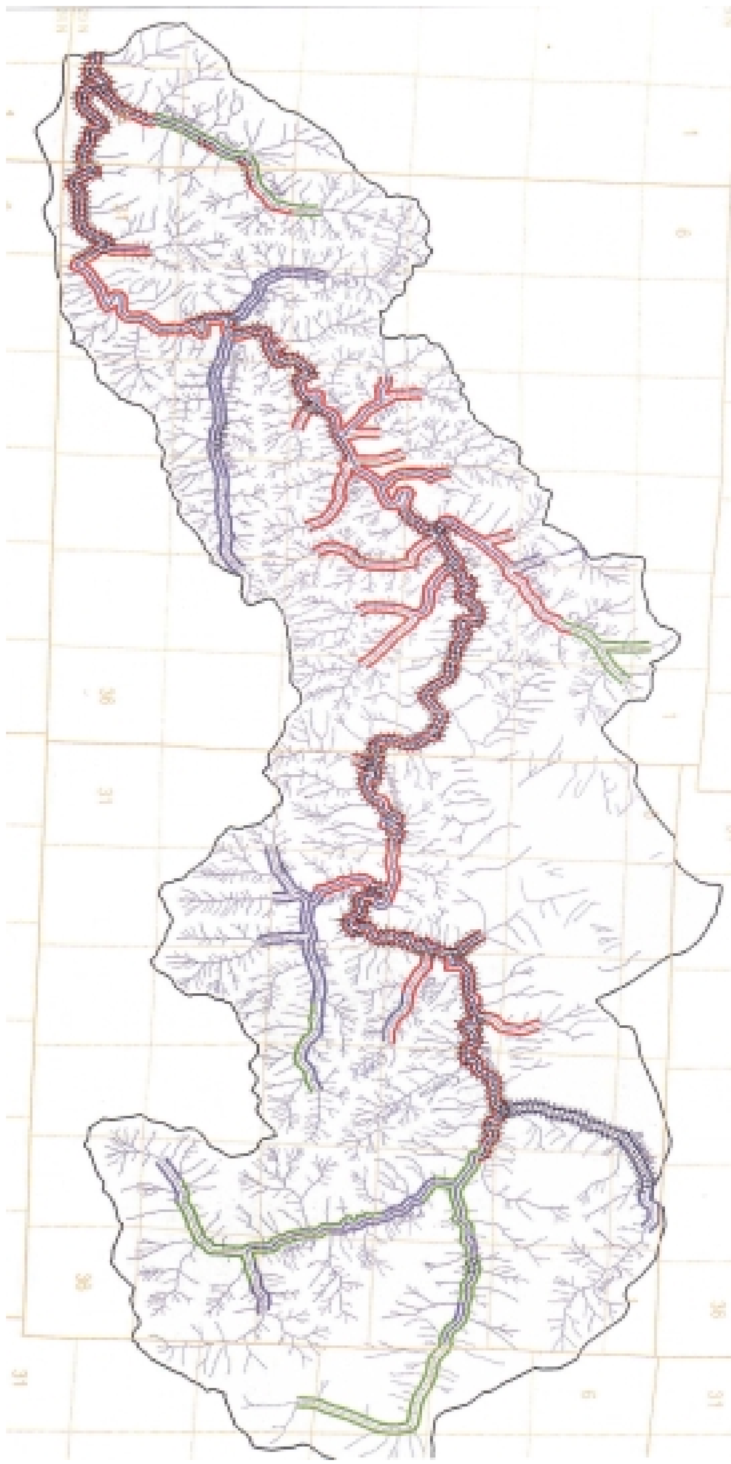
Historically, the Calawah Watershed was dominated by late successional conifer stands of Sitka spruce and old-growth western hemlock and alder, but the riparian has been impacted by fire and logging (U.S. Forest Service 1996). In the North Fork Calawah, the upper watershed has wide riparian buffers and good LWD recruitment (Figure 6), but downstream, the Forks fire and early timber harvest practices has changed the historically conifer riparian to 37% hardwood. In addition, about 400' of riparian was lost in the drying reach when a debris jam diverted the river (U.S. Forest Service 1996).

Riparian conditions are "poor" in lower West Cool Creek, lower Devils Creek, 20.0183, 20.0184, in the mainstem of the North Fork Calawah River upstream of Albion Creek, and in some reaches of the Sitkum River (Map 6b) (Table 8). "Good" riparian conditions are found throughout the South Fork Calawah in the Olympic National Park, as well as in East Cool Creek, upper Albion Creek, and the upper North Fork Calawah River. Most of the North Fork Calawah mainstem, Hyas Creek, and the Sitkum River rated "fair".

Table 8. North Fork Calawah LWD and Shade Condition (U.S. Forest Service 1996).

Stream	Dominant Type Riparian	Future Near-Term LWD	Future Long-Term LWD	Shade
Devil's Creek	Mixed and Deciduous Young	Fair	Good	Good
Streams 183A& 184	Mixed and Deciduous Young	Poor	Good	Good
Lower NF Mainstem	Mixed and Deciduous Young	Poor	Poor in deciduous areas	Naturally Poor
Middle NF Mainstem	Mixed and Deciduous Young	Poor	Poor	Poor
Upper NF Mainstem	Young Deciduous; Mixed Old	Poor in decid., Good in mixed.	Poor in deciduous, Good in mixed.	Naturally Poor
Western Cool Creek	Young Deciduous (lower reaches) and Mixed; Mature Conifer	Good except Poor in lower reaches	Good except Poor in lower reaches	Good
Fahnestock	Young Mixed	Poor	Good	Good
Eastern Cool Creek	Young and Old Conifer and Mixed	Fair	Good	Good
Albion Creek	Young Mixed in lower, Conifer upstream	Good (upper); Poor (lower)	Good (upper); Fair (Lower)	Poor
Pistol	Old Mixed Conifer	Good	Good	Poor

Figure 6. Near-term LWD recruitment potential in the North Fork Calawah Watershed (U.S. Forest Service 1996). Green=good recruitment, blue=fair recruitment, red=poor recruitment.



In the North Fork Calawah, the quantity of pool habitat measured by percent pools by surface area, rated “poor” in the upper mainstem, Eastern Cool Creek, Albion Creek, and Pistol Creek (U.S. Forest Service 1996. One segment in the lower mainstem was rated “good”, and another rated “fair”. Western Cook Creek and the lowest segment of the mainstem rated fair. There was “poor” pool spacing in the mainstem, Eastern Cool Creek, and Pistol Creek, with “fair” ratings in Albion Creek, the upper mainstem, and Western Cool Creek (Table 9). Pool habitat rated “fair” in Devil’s Creek under a different assessment (U.S. Forest Service 1996). See the Assessment Chapter for details on the target standards.

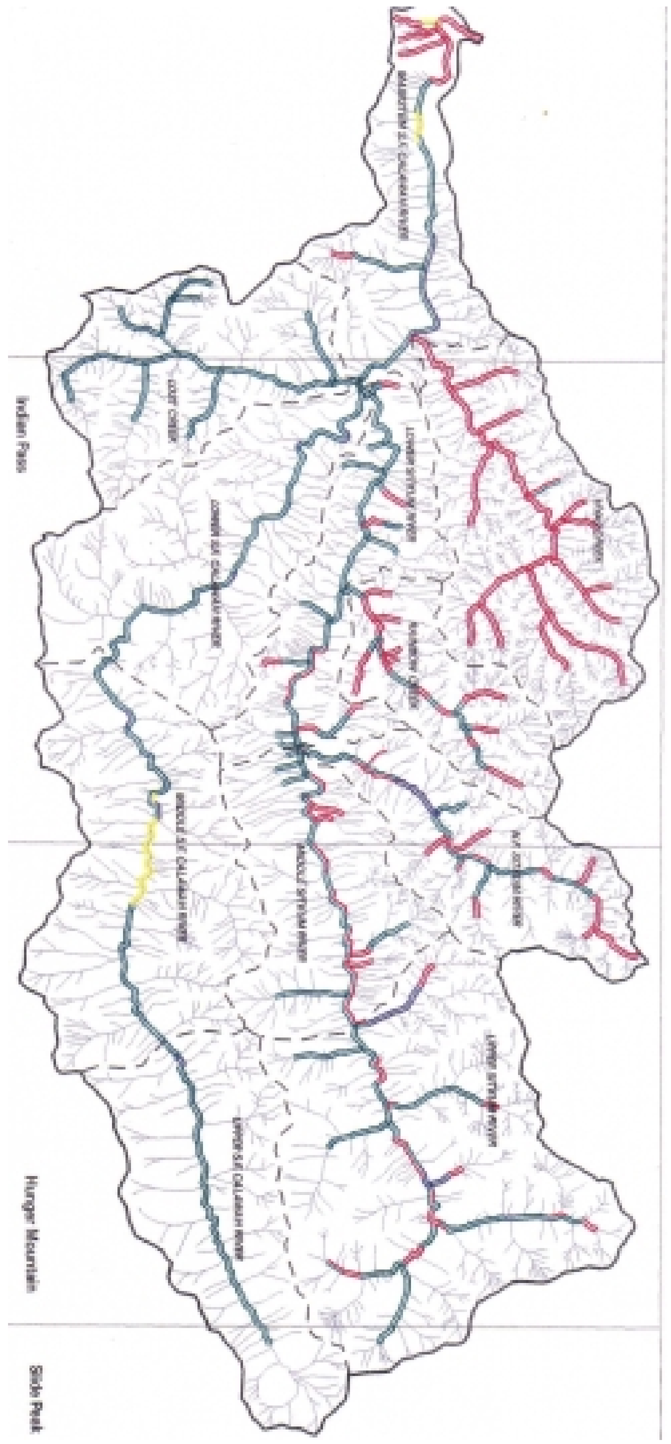
Table 9. North Fork Calawah Pool Habitat (U.S. Forest Service 1996).

Stream	Percent Pools	Rating based upon standards	Pool Spacing (CW/Pool)	Rating based upon standards
Lower mainstem (RM 0-7.8)	49-55%	Fair-Good	4.8-5.4	Poor
Upper mainstem (RM 15-21)	17-20%	Poor	3.6-5.5	Fair-Poor
Western Cool Creek	30-34%	Fair	3.9-4.5	Poor-Fair
Eastern Cool Creek	11-18%	Poor	4.3-7.0	Poor
Albion Creek	19-26%	Poor	3.2-3.9	Fair
Pistol Creek	18-21%	Poor	4.6-4.8	Poor

The South Fork Calawah River upstream of its confluence with the Sitkum River, lies entirely within the Olympic National Park. This area consists of mostly multi-storied late conifer with an excellent riparian zone (Map 6b) (U.S. Forest Service 1998). The nearby Sitkum River is in Forest Service lands, with 47% of the riparian in this area consisting of dense, late conifer and 17% is mixed with hardwoods. The remainder is mostly younger classes of conifer. Overall, the Sitkum River riparian is “good”, even though 41-43% of the Sitkum River riparian consists of small conifers or hardwoods (Map 6b).

The near-term LWD recruitment potential for the South Fork Calawah and Sitkum Watersheds is “good” in the South Fork Calawah, but “poor” in Hyas Creek, parts of Rainbow Creek, and small sections within the North Fork Sitkum Watershed (Figure 7) (U.S. Forest Service 1998).

Figure 7. Near-term LWD recruitment potential in the South Fork Calawah and Sitkum Watersheds (U.S. Forest Service 1998). Green=good recruitment, blue=fair recruitment, red=poor recruitment, yellow=naturally low recruitment.



In the South Fork Calawah and Sitkum Rivers, the quantity of pool habitat rated "fair to good", while in Hyas Creek, pool habitat rated "good" (U.S. Forest Service 1998).

Water Quality in the Quillayute Basin

Water quality problems abound throughout the Quillayute basin. Several stream reaches are on the 303(d) list, including sections within the Bogachiel, Soleduck, and Dickey drainages (DOE 1998). Within the Dickey watershed, parts of the West Fork, Middle Fork, and East Fork Dickey are on the 303(d) list for high water temperatures (Figure 8). Coal Creek, a tributary to the lower Dickey River, is also on the 303(d) list for high water temperatures. Other areas with high water temperatures include Dickey and Wentworth Lakes (see Lake Chapter), Skunk Creek, and Squaw Creek (Rayonier 1998, Module F). The high summer water temperatures can increase competition for coho salmon and steelhead and cutthroat trout rearing habitat, as well as contribute to an expanded distribution of squawfish (see Biological Processes section). Inadequate shade was documented on the mainstems of the East and West Dickey Rivers, and on Squaw and Thunder Creeks (Rayonier 1998, Module D). A few reaches of Ponds Creek and the Middle Dickey River also lacked adequate shade. Most of the smaller tributaries have good shade.

These listings have resulted in a "poor" water quality rating for the Dickey watershed (see Assessment Chapter for criteria). Because the Dickey sub-basin is one of the more productive coho salmon drainages in Washington State, the high water temperatures are a major limiting factor, impacting coho salmon (as well as steelhead trout) summer rearing habitat.

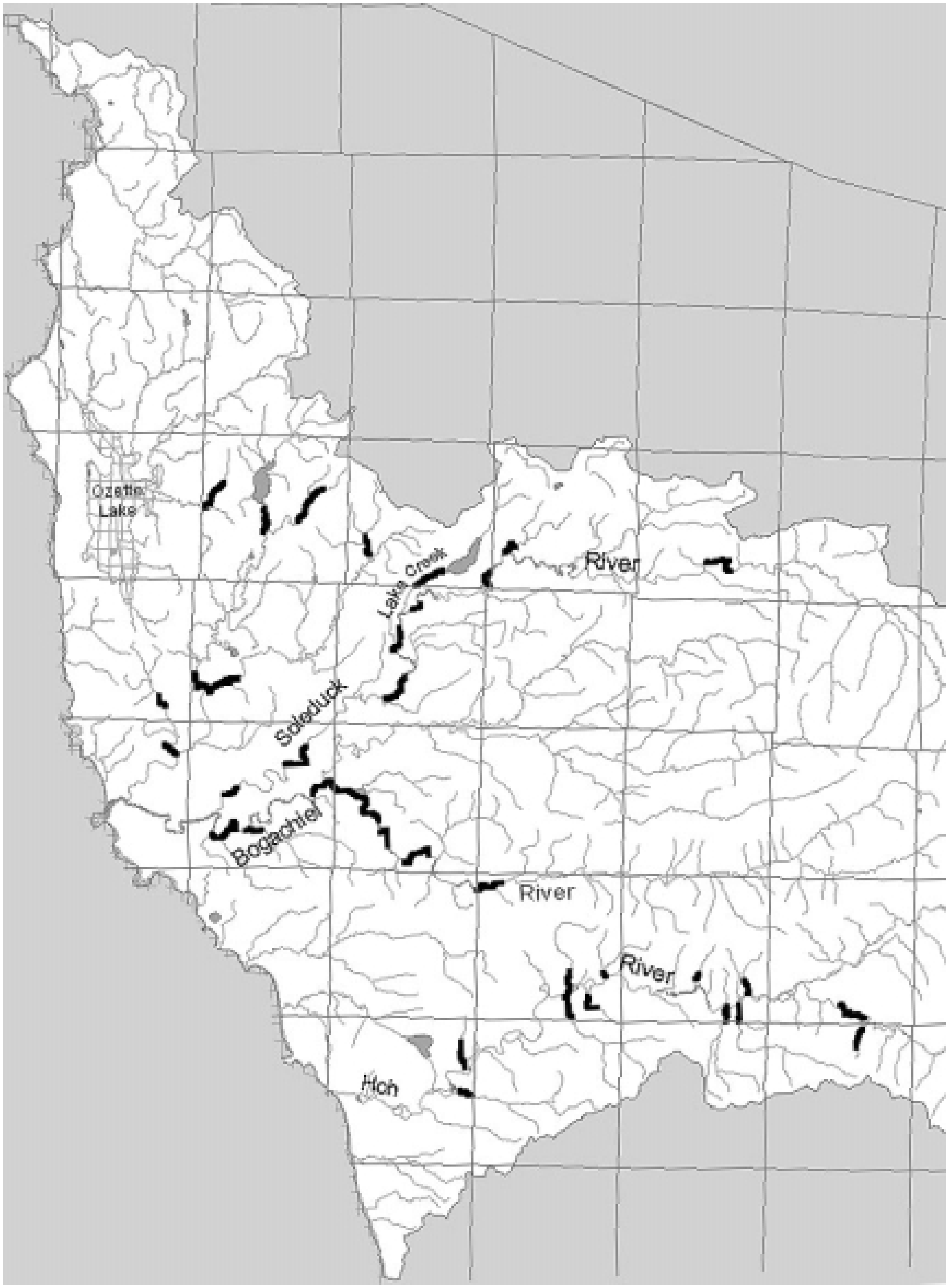
Several reaches of the mainstem Bogachiel are on the 303(d) list for either high water temperature and/or low dissolved oxygen (Figure 8) (DOE 1998). The two segments with both high water temperatures and low dissolved oxygen are located near RM 0 and RM 20. Other reaches of the mainstem Bogachiel River listed for warm water temperatures are located near RMs 8.7, 9, 9.8, 12.6, and 15.7 (DOE 1998). Maxfield Creek, a tributary to the Bogachiel, is also listed for high water temperatures. Turbidity is a problem in the Bogachiel (Bishop and Morgan 1996). These problems have resulted in a "poor" water quality rating for the Bogachiel downstream of RM 16. Three other tributaries (Mosquito Creek, Kahkwa Creek, and an unnamed stream) to the upper Bogachiel had water temperatures that exceeded State standards, but these are located in the Olympic National Park in old growth forest, and represent natural conditions.

High water temperatures were measured in the mainstem North Fork Calawah and in Devil's, Fahnestock, and Eastern Cool Creeks, and these stream reaches were on the 303(d) list in 1996. However, recent discussions have concluded that these water temperatures were natural and the result of the geological composition of the region. They have since been removed from the 303(d) list (DOE 1998). Due to the lack of exceedances from degraded habitat, the water quality for the North Fork Calawah drainage is rated "good" for this assessment (see Assessment Chapter for criteria).

High water temperatures are also a problem in Sitkum River and Hyas Creek of the South Fork Calawah drainage (U.S. Forest Service 1998). In all but one monitored stream, summer water temperatures were warmer than the Class AA standard, and often reached 18-20^{o}C. These temperatures result in a "poor" rating for water quality in these streams. The exception was in Lost Creek (located within the Olympic National Park), that had adequate water temperatures. Shade was below target in 54% of the upper and middle Sitkum River and in 27% of the North Fork Sitkum River, and these changes in riparian vegetation are a major cause of the water temperature problems (U.S. Forest Service 1998). Because of the low shade, these three areas rated "poor" for water quality. Other areas of the Sitkum and South Fork Calawah Rivers rated "good" for water quality.

In the Soleduck drainage, several reaches of the mainstem are on the 303(d) list for high water temperatures. Listed segments for high water temperature are located at RMs 6.5, 13, 19, 22.1, 23.8, and 44.9 (Figure 8). Three reaches have been listed for low dissolved oxygen as well, including locations near RMs 19, 22.1 and 44.9. Two tributaries to the Soleduck River have also been placed on the 303(d) list. Lake Creek is listed for both low dissolved oxygen and high water temperatures, and Beaver Creek is listed for temperature exceedances (DOE 1998). In addition to these streams, Goodman Creek, Bear Creek, and Swanson Creek have all had warm water temperatures (>16^{o}C) (U.S. Forest Service 1995). This results in "poor" ratings for the listed reaches of the mainstem Soleduck, Lake Creek, Beaver Creek, Goodman Creek, Bear Creek and Swanson Creek.

Figure 8. WRIA 20 stream reaches on the 1998 Candidate 303(d) List (DOE 1998).



Water Quantity in the Quillayute Basin

Dickey Sub-Basin

Dickey River flows are driven by highly seasonal rainfall, with most occurring from October through April, peaking in December (Rayonier 1998, Module E). There is not a significant rain-on-snow zone in this sub-basin. Current stands are dominated by 12-20 year old trees, resulting in a "poor" rating for hydrologic maturity (see Assessment Chapter for criteria). Also, in December, 1999, considerable habitat degradations occurred from the peak flow event, including a loss of LWD, filling of pools, and increased sedimentation.

Low summer water flows are also a concern. Groundwater reservoirs that feed streams in the summer are small (Rayonier 1998, Module E), and there is the possibility that the extensive timber harvest contributes to lower flows by reducing fog-drip in the Sitka Spruce zone (Harr 1982). Because the Dickey Sub-Basin has high levels of coho salmon productivity, summer rearing habitat is important and a better understanding of reductions (such as fog drip effects) to summer flows is a data need.

Soleduck Watershed

For most of the Soleduck watershed, stream flows closely follow precipitation patterns, with highest precipitation levels in December and January and lowest levels in July and August (U.S. Forest Service 1995). The eastern region typically has snow cover from December through April. Rain-on-snow events can occur in this region, but much of this area lies within the Olympic National Park and represents natural conditions. The exceptions to this are Kugel Creek, Camp Creek, Goodman Creek and the South Fork Soleduck River. These streams lie in the rain-on-snow zone and were logged beginning in the 1940s for Kugel and Camp Creeks with later logging in Goodman Creek and the South Fork Soleduck (U.S. Forest Service 1995). The extensive logging has increased the risk of damaging peak flow events. Evidence of changes is already noted, such as bank erosion, gravel bar movement, and scour. The loss of LWD and other roughness elements within these streams worsens the effects of peak flows.

Major floods have occurred in 1934, 1935, 1949, 1950, and 1956. In the last two decades, there have been a greater than expected number 2-10 year flow events, but the increase is likely due to increased precipitation trends (El Nino) (U.S. Forest Service 1995).

Low summer flows are also a concern within the Soleduck watershed. Several streams have a natural geology that leads to low flows. These include Gunderson Creek, Maxfield Creek, Shuwah Creek, Bockman Creek, Lake Creek, and Kugel Creek.

However, three human-caused actions may potentially worsen the already naturally low flows. One action is water withdrawals. In 1995, permitted water withdrawals totaled 135 cfs, which is 40% of an average August flow and 70% of a dry August flow (U.S. Forest Service 1995). Not all of this water is actually withdrawn, but the potential exists to create a major limiting factor for coho and steelhead summer rearing. Early-timed adults such as summer chinook and summer coho might also be impacted.

Another potential impact on summer low flows is the loss of large trees that can collect fog drip. Large trees collect moisture from fog, especially Sitka spruce zones like that found throughout the lower Soleduck watershed (U.S. Forest Service 1995). The potential effect on fog drip is a data need, and the following streams are expected to have the greatest impact: Gunderson Creek, Maxfield Creek, Tassel Creek, Shuwah Creek, Bockman Creek, and Lake Creek.

The third potential impact on summer low flows is the loss and change of character of wetlands. Logging, agriculture, urban development, suburban development and road construction have led to a direct loss of at least 4 acres of wetlands in the Soleduck watershed (U.S. Forest Service 1995).

The age of vegetation (hydrologic maturity) is thought to play a role in stream flow buffering, but the precise impact of hydrologic maturity on salmon production remains a data need. Currently, several watersheds within the Soleduck drainage are rated "poor" for hydrologic maturity (<60% mature). These include Bear Creek (35% mature), Upper Bear Creek (37% mature), South Fork Bear Creek (47% mature), Beaver Creek (44% mature), Lake Creek (37% mature), Goodman Creek (44% mature), Camp Creek (37% mature), Kugel Creek (51% mature), and the South Fork Soleduck River (48% mature)(U.S. Forest Service 1995).

Several other watersheds rated "good" for hydrologic maturity, such as the North Fork Soleduck, Maxfield Creek, Tassel Creek, Shuwah Creek, Bockman Creek, and Alckee Creek. The U.S. Forest Service lands upstream of Bear and Kugel Creeks are now late seral reserves, which means that they will no longer be clear-cut, but commercial thinning will be allowed (U.S. Forest Service 1995).

South Fork Calawah and Sitkum Rivers

In the South Fork Calawah and Sitkum Drainages, the highest peak flow event was measured in 1991. Large floods are uncommon in these drainages, but 2-year reoccurrence flows have been greater than a 60% occurrence since 1990. While the increasing trend in peak flows is likely related to an increased trend in precipitation, the timing and magnitude of peak flows have likely increased from the combination of high road density and a dense stream network. The increased peak flows corresponds to an increased number of landslides since 1973 (U.S. Forest Service 1998).

The majority of the South Fork Calawah and Sitkum Watersheds are hydrologically mature (69%), with the least areas of mature vegetation in the lower Sitkum River (55% hydrologically mature), North Fork Sitkum (47%), and Hyas Creek (40%) (U.S. Forest Service 1998). These reaches are considered "poor" using our assessment criteria, while the South Fork Calawah has a "good" hydrologic maturity rating (see Assessment Chapter).

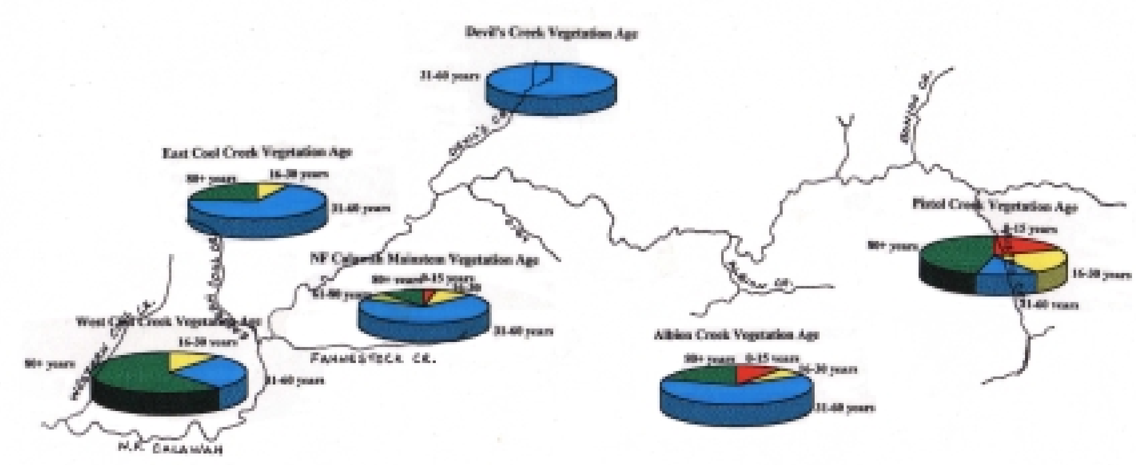
Dewatering is a problem in Hyas Creek, Rainbow Creek, and the North Fork Sitkum River (U.S. Forest Service 1998). It is caused by increased sedimentation coupled with high sediment transport due to a lack of LWD. These areas are rated "poor" for water quantity.

North Fork Calawah River

A significant rain-on-snow zone lies in the North Fork Calawah Watershed, which results in increased sensitivity to peak flow increases due to timber harvest (U.S. Forest Service 1996). While large peak flows are driven primarily by rainfall, rain-on-snow events increased the frequency of 1-4 year flow events. Areas of the mainstem North Fork Calawah have experienced channel migration and bank erosion due to increased flows from the upper watershed. However, the age of the vegetation throughout the North Fork Calawah Watershed is relatively mature compared to other watersheds in western Washington. Nearly all areas assessed had trees that were 31 years or older as the dominant age of vegetation (Figure 9) (U.S. Forest Service 1996). For this reason, the North Fork Calawah watershed is rated "good" for hydrologic maturity.

In the North Fork Calawah River, the mainstem from RM 8-16 dries every summer, decreasing summer rearing habitat by 47% (U.S. Forest Service 1996). This is a natural condition resulting from the highly porous and conductive glacial outwash that fills the valley (U.S. Forest Service 1996). The tributaries near this reach are important as low flow refuges.

Figure 9. Vegetation age in the North Fork Calawah Watershed (data from U.S. Forest Service 1996).



<u>Lake Habitat in the Quillayute Basin</u>

There are two lakes within the Quillayute basin that are particularly important for salmon and steelhead production. Dickey Lake covers 520 acres, and greatly influences temperature and sediment regimes in the West Dickey River. Warm water temperatures are a problem in Dickey Lake and Wentworth Lake.   The warm temperatures are natural because Dickey Lake averages only 25' in depth (Rayonier 1998, Module E).   Both of these lakes drain into the Dickey sub-basin and contribute to warmer stream temperatures. However, the temperatures in Dickey Lake would also directly impact coho salmon, which use the lake for rearing. Smolt production from Dickey Lake is low compared to nearby streams. For example, in 1996, coho smolts from Dickey Lake were estimated as 143/sq. mile, while production from a nearly tributary (number 0132) was 1220/ sq. mile (Haymes and Tierney 1996). Until the cause of low productivity from Dickey Lake is determined and addressed, projects in this area should have a lower priority.

Lake Pleasant is located within the Soleduck drainage. It covers 500 acres at an elevation of 390'. The only known self-sustaining sockeye spawning population in the Quillayute basin spawns along the beaches located along the margins of Lake Pleasant (U.S. Forest Service 1995). In addition to sockeye, Lake Pleasant provides habitat for a unique resident coho salmon population as well as rearing habitat for the anadromous fall coho salmon stock. Warm water temperatures occur in the surface waters in the summer months, typically around 20-22^{o}C. These warm water temperatures contribute to high temperatures in Lake Creek, which drains Lake Pleasant. The lake has stable levels of dissolved oxygen and low levels of nutrients. In the past, Lake Pleasant was poisoned for fisheries reasons. This may have altered the native stocks. Currently, the southern half of the lake shores are fairly densely inhabited. Potential impacts of this development should be examined.

Biological Processes in the Quillayute Basin

The minimum spawning escapement goals for the Quillayute system have been met in all but 6 years in the last 20 years for fall coho, and all but 2 years in the last 20 years for fall chinook and steelhead trout (Rayonier 1998, Module F). This results in a "good" rating for nutrient cycling (see Assessment Chapter for criteria).

Squawfish are present in Dickey Lake, and might be native to the watershed (Rayonier 1998, Module F). However, concern exists that they have expanded distribution throughout the West Dickey River, and this expansion might be due to warmer water temperatures, which are preferred by squawfish. Squawfish have been seen as far down as near the mouth of the Dickey (Warren Scarlett, DNR, personal communication; Dick Goin, personal communication), and have recently been seen in the East Fork Dickey, an area where they were not found in the past (Dick Goin, personal communication). The warm water temperatures are at least partially the result of reduced shade (see Water Quality section). Squawfish are known predators on juvenile salmonids, and it is speculated that the low coho smolt production from Dickey Lake is due to squawfish predation. The impact of predation on coho salmon in Dickey Lake and the West Dickey River remains a data need. However, the presence of squawfish in the West Dickey River is another indicator that warm water temperatures are a major habitat problem, not only directly effecting salmon production, but also indirectly by providing more ideal habitat for predators.

Hoh Basin

Loss of Access in the Hoh Basin

There are two major access problems in the Hoh Basin. One is culverts and the other is caused by cedar spalts. Cedar spalts are waste wood left over from salvage operations. Large instream accumulations of spalts can block fish passage, impede water flows leading to warmer water temperatures, and degrade water quality by leaching tanins into the water.

Table 10 lists streams currently known to be impacted by cedar spalts (Jill Silver, Hoh Tribe, personal communication). The number of affected feet as well as township, range, and section numbers are also provided. They are listed in order of impact based upon these criteria in the following order: 1) stream length affected; 2) stream type (larger streams have a higher priority); 3) streams in the Hoh drainage had a higher priority than smaller systems, and 4) those located further downstream had a higher priority (juvenile rearing and over-wintering). Recently, Alder Creek and Hell Roaring Creek were cleaned of spalts, but continued monitoring after high water events is needed to assure that the channels have been adequately cleared.

Table 11 lists currently known blocking culverts within the Hoh basin (Jill Silver, Hoh Tribe, personal communication). These are listed in order of impact based upon 1) quantity of habitat above culvert and 2) number of species impacted. Some of these culverts impact only cutthroat trout, and these culverts were listed after the culverts blocking salmon and steelhead, regardless of quantity of habitat blocked. (This report generally has not included cutthroat trout issues.)

Table 10. Hoh Basin Reaches Impacted by Cedar Spalts (Jill Silver, Hoh Tribe, personal communication).

Stream	Township/Range/ Section	Stream Length Impacted (feet)	Owner
Fullerton Tributary	26N13W26	6,000	Rayonier
Steamboat Cr.	25N13W10	5,400	Rayonier
Braden Cr.	26N12W30	4,000	State
Cedar Cr.	25N12W6	3,500	Rayonier
Cedar Cr.	26N13W35	3,300	Rayonier
Sand Cr.	25N13W3	2,500	Rayonier
Nolan Cr.	26N12W15	2,000	State
Steamboat Cr.	25N13W11	2,000	State
Sand Cr.	25N13W11	1,400	State
Clear Cr.	26N11W4	1,300	State
Pins Cr.	26N12W16	1,200	State
Nolan Cr.	26N12W15	1,100	State
Nolan Cr./Chow Chow	26N12W24	1,000	Rayonier
Sand Cr.	25N13W12	1,000	State
Nolan Cr.	26N12W19/20	1,000	State
Nolan Cr.	26N12W26	1,000	Rayonier
Nolan Cr.	26N12W29	1,000	State
SF Cedar Cr.	25N13W2	1,000	State
Nolan Cr.	26N12W20	800	State
Nolan Cr.	26N13W24	800	Rayonier

Elk Cr.	26N11W9	800	State
Clear Cr.	26N11W3	800	State
Sand Cr.	25N13W11	800	Rayonier
SF Cedar Cr.	25N13W1	700	State
Nolan Cr.	26N13W24	600	John Hancock
Lost Cr.	26N12W9	500	John Hancock
Red Cr.	27N11W33	500	John Hancock
Cedar Cr.	26N13W35	500	Avery ‘80
Sand Cr.	25N13W2	500	State
Steamboat Cr.	25N13W9	500	State
Nolan Cr.	26N12W20	400	State
RB Trib to Hoh	27N12W28	300	State
Steamboat Cr.	25N13W11	300	Rayonier
Snell Cr.	27N12W23	300	State
Clear Cr.	26N11W3	300	State
Anderson Cr.	26N13W2	200	Rayonier
Winfield Cr.	26N11W5	200	State

Table 11. Hoh Basin blocking culverts (Jill Silver, Hoh Tribe, personal communication).

Stream	Township/ Range/ Section	Road Name	Stream Length Impacted (feet)	Species Impacted
RB Trib. To Hoh	26N12W06	H. 4060 Rd. Cottonwood	4,000 + 20 acres off-channel rearing	Coho
Dismal Cr.	27N11W35	Upper Hoh Rd	10,500	Coho, Steelhead, Cutthroat
LB Trib to Alder Cr.	27N12W23	Upper Hoh Rd	10,500	Coho, Cutthroat
Nolan Creek	26N13W24	N. 1000 Rd.	10,000	Coho, Steelhead, Cutthroat
RB Trib. To Hoh	26N13W22	8.3 mi on Oil City Rd.	5,700	Steelhead, Cutthroat
Braden Cr.	26M12W29	Old Pen Ply Rd.	5,500	Coho, Cutthroat
Nolan	26N12W20	N 1000 Rd. at Pen Ply Rd.	5,200	Coho, Steelhead, Cutthroat
RB Trib. To Hoh (2 culverts)	26N12W04	Sundowner Lots Rd.	Several acres off-channel rearing	Coho, Cutthroat
RB Trib. To Hoh (2 culverts)	26N12W04	Cottonwood Rd. (Rayonier)	Several acres off-channel rearing	Coho, Cutthroat
Canyon Cr.	27N11W25	9.7 mile Upper Hoh Rd.	4,800	Steelhead, Cutthroat
Cassel Cr.	26N12W07	3.5 mi on Oil City Rd.	4,000	Steelhead, Cutthroat
RB Trib. To Hoh	27N12W33	0.5 mi on Oil City Rd.	4,000	Steelhead, Cutthroat
Mosquito Creek	26N13W10	G 3700 Rd	4,000	Coho, Cutthroat

Cedar Cr.	26N12W32	Old Pen Ply Rd.	3,600	Coho, Steelhead, Cutthroat
RB Trib. To Goodman Cr.	27N13W16	2.7 mi on G 2100 Rd.	3,500	Coho, Steelhead, Cutthroat
Rock Cr.	27N11W04	H 3100 Rd.	3,300	Steelhead, Cutthroat
Cedar Cr. Trib.	26N12W32	N 1130 Rd.	3,000	Coho, Steelhead, Cutthroat
LB Trib to Goodman Cr.	27N14W24	G 3300 Rd.	3,000	Coho, Cutthroat
RB Trib to Hoh	26N12W5	Oil City Rd. Two Culverts	2,500	Coho, Cutthroat
Mosquito Creek	26N13W10	G 3700 Rd	2,500	Coho, Cutthroat
RB Trib to Hoh	26N13W16	H 4500 Rd.	2,500	Steelhead, Cutthroat
LB Trib to Goodman Cr.	27N14W24	G 3310 Rd.	2,500	Steelhead, Cutthroat
LB Trib to Goodman Cr.	27N14W24	G 3310 Rd.	2,000	Coho, Steelhead, Cutthroat
Nolan Cr.	26N12W22	N 1000 @ N 1060 Rd.	2,000	Coho, Cutthroat
Nolan Cr.	26N12W22	N 1063 Rd.	1,600	Coho, Steelhead, Cutthroat
RB Trib to Goodman Cr.	27N13W16	0.3 mi on G 2170 Rd.	1,500	Coho, Cutthroat
Nolan Cr.	26N12W20	2 mi on N 1000 Rd.	1,300	Coho, Cutthroat
Cedar Cr.	26N12W32	Old Pen Ply Rd.	1,000	Possible Coho
RB Trib to Hoh	26N12W06	3 mi on Oil City Rd.	4,000	Cutthroat

Nolan Cr.	26N12W28	Pen Ply Rd.	3,600	Cutthroat
LB Trib to Pole Cr.	27N11W27	8.5 mi Upper Hoh Rd.	3,500	Cutthroat
Elk Creek Trib	26N11W04	Clearwater Mainline	3,200	Cutthroat
RB Trib to Hoh	26N13W16	0.9 mi on H 4500 Rd.	2,500	Cutthroat
RB Trib to Goodman Cr.	27N13W15	2.1 mi on G 2100 Rd.	2,000	Cutthroat
RB Trib to Iron Maiden	27N10W31	H 1000 H 1064 Rds.	1,700	Cutthroat
RB Trib to Goodman Cr.	27N13W15	2.4 mi on G 2100 Rd.	1,500	Cutthroat
RB Trib to Hoh	26N13W15	0.6 mi on H 4500 Rd.	1,500	Cutthroat
RB Trib to Hoh	26N13W16	H 4500 Rd.	1,300	Cutthroat
LB Trib to SF Hoh	27N10W33	H 1000 Rd at H 1070 Rd.	1,000	Cutthroat
Cedar Cr.	25N12W06	N 1113 Rd.	1,000	Cutthroat
RB Trib to Goodman Cr.	27N13W16	0.1 mi on G 2170 Rd.	1,000	Cutthroat
Iota Cr.	27N10W32	H 1000 Rd. 6.5 mi	700	Cutthroat
Nolan Cr.	26N12W28	Pen Ply Rd.	600	Cutthroat
RB Trib to Goodman Cr.	27N13W16	2.5 mi on G 2100 Rd.	500	Cutthroat
Hell Roaring Cr.	Numerous Blockages, not yet specified			

Floodplain Impacts in the Hoh Basin

The Hoh basin has naturally abundant river-floodplain bottom areas, which have channel complexes that intercept wall-based spring-fed channels, valley-wall, and terrace tributaries (Jim Jorgensen, Hoh Tribe, personal communication). These often form networks that often flow parallel to the mainstem for significant distances (Hatten 1991). The terrace tributaries and other floodplain habitat (wetlands, vegetated depressions, ponds, etc) are important, stable habitat, particularly as over-wintering habitat for coho salmon (Peterson and Reid 1984) (Map 7). They are less impacted by storm flows than newer river meander channels, and have abundant pool habitat, vegetation, and low gradients. The alluvial floodplain is also the site of significant exchange between nutrient rich groundwater and surface water, which leads to high levels of productivity in an unaltered system (Poole and Berman in prep.).

There has been a loss in this type of off-channel habitat (WA DNR in prep.), and probable degradation of groundwater inputs, which have likely reduced water quality (John McMillan, Hoh Tribe, personal communication). Also, the quality of this type of habitat has been degraded, especially from logging in the channel migration zone, which has resulted in decreased levels of wood, and from increased sedimentation that easily accumulates in the low water velocity wetlands and off-channel habitat (WA DNR in prep.). These degraded areas are outlined in Map 7. Given the importance of lateral habitat in the middle and lower Hoh River, the floodplain habitat should be given a high restoration and conservation priority.

A common floodplain impact in the Hoh sub-basin is the presence of riparian roads. Some of these roads closely parallel the streams, acting as dikes, disconnecting potential off-channel habitat, and increasing sediment inputs into the stream. The most heavily impacted streams are listed in Table 12. Using the rating criteria outlined in the Assessment Chapter, several streams rated “poor” for floodplain impact, including Nolan Creek tributary 20.0431, the mainstem Hoh River, and Owl Creek. Although the Hoh River mainstem rated “fair” using the assessment criteria for riparian road impacts, there is great concern about the impacts from the Upper Hoh Road. This road constricts the mainstem Hoh River, and has been washed out many times. When the road is damaged, more river bank armoring has occurred, which further constricts the mainstem Hoh River. Because of the armoring and road instability, the rating condition for the Hoh River mainstem was downgraded to “poor”.

Other types of floodplain impact are channel incision and channelization. These problems have been documented in Owl, Spruce, Alder, Maple, Dry, East Fork Hell Roaring, and Split Creek, as well as constriction from a bridge in the South Fork Hoh River (WA DNR in prep.). Streams with these problems have been rated “poor” for floodplain conditions.

Table 12. Riparian Roads in the Hoh Basin.

Stream	Range (RM) Impacted	Species Impacted	Habitat Rating
Hoh River	0-1.1, 19.5-20.2, 44-46, 47.5-48.7	Coho, steelhead, chinook, sockeye	Poor
Nolan Creek	1-3	Coho, steelhead, fall chinook	Fair
Nolan trib. 20.0431	0-1	Coho, steelhead	Poor
Winfield Creek	2-3.5	Coho, steelhead, fall chinook	Fair
Owl Creek	0-1.8	Coho, steelhead, fall chinook	Poor
Mt. Tom Creek	1.3-3	Steelhead, coho, summer chinook	Fair
South Fork Hoh River	Numerous crossings	Fall chinook, coho, steelhead, sockeye	Fair
Steamboat Creek	0.1-1.5	Coho, steelhead	Fair

Goodman Creek contains a high density of wetlands, indicating high ground-water inputs (Jill Silver, Hoh Tribe, personal communication). However surveys are needed within the Goodman Creek basin to determine fish use and access.

Streambed Sediment Conditions in the Hoh Basin

While the upper Hoh lies within the Olympic National Park and the lower Hoh within the Hoh Indian Reservation, the middle Hoh is surrounded by private landowners and Washington DNR land, and is the location of numerous impacts to salmonids. In the Huelsdonk Ridge area of the middle Hoh, landslides have increased 6-7 times over historic levels with the increase associated with clearcutting (63%) and roads (27%) (Schlichte 1991). Debris flows are common in the Hoh sub-basin, scouring channels and transporting gravel and LWD downstream (WA DNR in prep). Debris flows have also resulted in a reduction of macroinvertebrates, food web items for salmonids. Populations of macroinvertebrates are 75% higher in the Olympic National Park reaches compared to areas impacted by debris flows (McHenry 1991).

The increased transport of gravel due to debris flows has resulted in reaches where spawning gravels are limited. These include: Alder, Willoughby, Spruce, Canyon, and Split Creeks, streams important for steelhead and cutthroat trout as well as coho salmon (WA DNR in prep.). These streams rated "poor" for sediment quantity.

The quality of spawning gravels has been degraded by increased fine sediment from mass wasting and road erosion. Extremely high levels of fines have been documented in Iron Maiden Creek (57%) and Canyon Springs Creek (45%), which were sampled the summer after landslides occurred in the area (WA DNR in prep.). Sediment from Iron Maiden Creek delivers to sensitive side channel habitat. Fines were also rated "poor" in Spruce (20%), and Brandenberry (21%) (WA DNR in prep.), as well as in Lost Creek (21%) (Cederholm and Scarlett 1997). "Fair" (11-17%) levels of fines were in Alder, Elk, and Split Creeks (WA DNR in prep.) and in Anderson, and Braden (Cederholm and Scarlett 1997). Boundary Creek was noted for high sediment delivery to the mainstem Hoh (WA DNR in prep.).

Another sedimentation issue in the Hoh basin relates to channel incision caused by a lack of LWD and increased sediment transport. The incision has exposed unstable clay layers that release fine sediments into the streams (Jill Silver, Hoh Tribe, personal communication). Aggradation and excessive sedimentation has been observed in Owl and Nolan Creeks, and these have been rated "poor" for sediment quantity (Dick Goin, personal communication).

Road density is directly related to the volume of fine sediment transported via precipitation runoff. Road densities were either "good" or "fair", using the standards described in the Assessment Chapter. In Anderson, Braden, Lost, and Winfield Creeks, road densities were "good", while in Alder, Elk, Nolan, Owl, Pins, and Willoughby Creeks, the road densities were fair (Cederholm and Scarlett 1997). None of the watersheds examined were classified as "poor" for road density.

Stream bank erosion has occurred in areas impacted by cedar spalt dams. As the dams float up and down in high and low flows, they carve the stream banks and increase fine sediments (Jill Silver, Hoh Tribe, personal communication). Currently impacted streams include Braden, Clear, Red, Lost, Pins, Snell, Anderson, Winfield, Willoughby, and Nolan Creeks in the Hoh basin as well as in Cedar, South Fork Cedar, Sands, and Steamboat Creeks. These streams were rated "poor" for sediment quantity.

Channel changes have greatly altered some of the middle Hoh tributaries. Scour in Owl Creek has impacted chinook salmon spawning habitat (WA DNR in prep.), and Spruce, Willoughby, and upper Alder Creeks no longer support coho salmon spawning due to mass wasting impacts. The mainstem Hoh River has changed in recent years as well (Dick Goin, personal communication). These streams are rated "poor" for channel stability.

In general, "good" LWD conditions are found in the upper Hoh and upper South Fork Hoh Rivers and tributaries, which are located within the Olympic National Park (Map 5b)

(John Meyer, Olympic National Park, personal communication). "Poor" LWD conditions are found throughout the remainder of the Hoh basin, with the exception of "fair" conditions in lower Willoughby Creek and "good conditions in upper Hell Roaring Creek (Map 5b) (Hatten 1994; Cederholm and Scarlett 1997; WA DNR in prep.).

Of special note is Owl Creek where counts of LWD are high, but most is non-functional, located outside of the ordinary bankfull width. Because of the location of LWD within Owl Creek, it was rated "poor" in this report. In addition, the larger key pieces of LWD were low in Anderson, Braden, Elk, Lost, Nolan, Pins, and Winfield, even though total number of pieces (small and large) were within acceptable range (Cederholm and Scarlett 1997). Because of the lack of key pieces, these streams were rated "poor". Several of these streams also had many of the LWD pieces located outside the wetted channel.

The lack of LWD has not only contributed to channel incision and instability, but has also resulted in reduced spawning gravel quantity, reduced pool habitat, and reduced ability of ground water and surface waters to mix. Very large pieces of woody debris are particularly important for the steep headwall tributaries of the Hoh (Jill Silver, Hoh Tribe, personal communication). Larger pieces are the only type of wood that will contribute to channel formation in these reaches. They also are important as nutrient dams and in maintaining genetic diversity of resident salmonids by effectively isolating populations.

While specific habitat survey data are lacking for the Goodman Creek basin, biologists have noted that from the G-2108 road to the bridge on G-3000, there is a lack of LWD and spawning gravel and there are signs of scour (Jill Silver, Hoh Tribe, personal communication). Reaches of the basin that are within the Olympic National Park have an old growth riparian and are rated "good" for instream LWD.

Riparian Conditions in the Hoh Basin

Historically the Hoh riparian consisted of old growth western hemlock and Sitka Spruce with lesser amounts of western red Cedar and Douglas fir (WA DNR in prep.). Natural disturbances of the riparian include wind, landslides, flooding and fire. Hurricane force winds occur in the region about every 20 years and especially impact southern exposure and flat-terrace areas such as Hell Roaring, Alder, Willoughby, Tower, Spruce, Canyon, Winfield and Elk Creeks. Many of these wind-damaged areas have regenerated with western hemlock or red alder (WA DNR in prep.). Natural landslides are common with debris flows noted in all major watersheds except Hell Roaring Creek. Flooding is common along the mainstem Hoh River, South Fork Hoh River, Winfield Creek, Elk Creek, and Alder Creek. Fire was a historic disturbance, but has been less frequent in the last 700 years due to climate changes.

In general, "good" riparian conditions are found in the upper Hoh and upper South Fork Hoh Rivers and tributaries, which are located within the Olympic National Park (Map 6b) (John Meyer, Olympic National Park, personal communication). The lower South Fork Hoh mainstem has a "fair" riparian, while nearby tributaries are "fair" to "good" (WA

DNR in prep.). Most of the mainstem Hoh River downstream of the South Fork has "poor" riparian conditions, as well as Pins Creek, lower Winfield Creek, lower Elk Creek, middle Willoughby Creek, Maple Creek, and several unnamed tributaries (Map 6c) (Jill Silver, Hoh Tribe, personal communication; WA DNR in prep.). "Good" riparian conditions were noted in Nolan, Anderson, Lost, lower Hell Roaring, upper Alder, upper Winfield, upper Elk, Owl, and some unnamed creeks. "Fair" conditions exist in Canyon, Spruce, lower Alder, upper Hell Roaring, and Braden Creeks (Map 6c).

Near-term LWD recruitment potential is poor throughout about 72% of the middle Hoh WAU (WA DNR in prep.). The worst tributaries for near-term LWD recruitment potential are: the South Fork Hoh River, Winfield Creek, Willoughby Creek, Tower Creek, Owl Creek, and Elk Creek. These were logged before adequate riparian buffers were required, and many were logged to the stream banks.

The quantity of pool habitat is "poor" in Owl, Willoughby, and Anderson Creeks, and "good" in Braden, Elk, Lost, and Pins Creek (Cederholm and Scarlett 1997). "Fair" pool habitat was documented in Alder, and Nolan Creeks, while deep pools (all less than 1/3 m) are lacking in upper Winfield Creek, which contributed to a high mortality of salmonids in August, 1999 (John McMillan, Hoh Tribe, personal communication).

In the Goodman Creek basin, there is a lack of deep pools and an alder-dominated riparian zone in the middle section of the mainstem (Jill Silver, Hoh Tribe, personal communication). This section is rated "poor" for this report. Reaches of the basin that are within the Olympic National Park have an old growth riparian and are rated "good" for riparian conditions.

In areas impacted by cedar spalts, the wood often covers the ground of the riparian zone, inhibiting further plant growth (Jill Silver, Hoh Tribe, personal communication). These impacted areas include Anderson, Willoughby, Winfield, Nolan, Braden, Clear, Red, Lost, Pins, and Snell Creeks in the Hoh basin, as well as Cedar Creek, Sands Creek, South Fork Cedar Creek, and Steamboat Creek. While small areas are impacted in Anderson, Red, Lost, and Snell Creeks, considerably quantities of habitat (see Access chapter) was impacted in all other areas, and these were rated as "poor" for riparian conditions.

Water Quality in the Hoh Basin

Several tributaries to the Hoh River are on the 1998 Candidate 303(d) list because of high water temperatures (Figure 8) (DOE 1998). Fisher, Willoughby, Rock, Elk, Canyon, Anderson, Alder, Line, Maple, Nolan, Owl, Split, Tower, and Winfield Creeks were listed in 1996, and are also on the 1998 Candidate 303(d) for high water temperatures. Most of these are located in the middle Hoh between Highway 101 and the confluence with the South Fork Hoh River. Line, Fisher, and Split Creeks are tributaries to the lower South Fork Hoh River, and Nolan and Anderson Creeks are in the lower Hoh region. Because of the Candidate 303(d) recommendation, all of these streams are rated as "poor" in water quality. In August, 1999, the conditions in Winfield Creek were so poor that extensive salmonid mortality occurred (John McMillan, Hoh Tribe, personal communication). Water temperatures ranged from 16-19^{o}C and dissolved oxygen ranged from 3-5 mg/L in the area that dead salmonids were found. In this area, the flows frequently go subsurface, and to what extent the subsurface flow is natural is unknown.

Streams impacted by cedar spalts have water quality problems such as low dissolved oxygen, very high acidity, and high water temperatures (Jill Silver, Hoh Tribe, personal communication).   Monitoring results showed that dissolved oxygen levels above spalt dams ranged from 3.5 mg/L to 6 mg/L, compared to significantly higher dissolved oxygen levels below spalt dams and to the standard of 9.5 mg/L.   Water temperatures were 4 to 5 ^{o}C warmer in the areas above the spalt dams compared to free flowing reaches. These water conditions appear to result in a lack of aquatic invertebrates that fish need for food and are the likely reason that salmonids were not found in the spalt dammed areas (Jill Silver, Hoh Tribe, personal communication). Currently impacted streams include Winfield Creek, Braden Creek, Clear Creek, Nolan Creek, Red Creek, Lost Creek, Pins Creek, Snell Creek, Anderson Creek and Willoughby Creek in the Hoh basin, and Steamboat Creek, Cedar Creek, Sands Creek and South Fork Cedar Creek in the small independent streams. These streams were rated as "poor" for water quality because of the cedar spalt impact.

In addition to spalts, the water quality problems in the Hoh basin might be a result of alterations to the alluvial aquifers (John McMillan, Hoh Tribe, personal communication). It has been shown in other basins that up to 90% of the watershed's productivity is derived from alluvial aquifers, which support rich populations of invertebrates, such as stoneflies, as well as vertebrates. As runoff and nutrients distribute from the steep upland slopes to the low gradient floodplain, the groundwater and surface waters mix to form areas of high productivity, particularly in the summer low flows when warm surface waters mix with nutrient-rich cool water. The alluvial aquifers contribute not only to productivity in the complex floodplain of the Hoh, but also cools water temperatures in the summer and slightly warms surface water in the winter (Poole and Berman in prep.). Removal of upland vegetation decreases the infiltration of groundwater on hillslopes, reducing baseflows in streams and therefore, reducing productivity and water temperature buffering. Excessive sedimentation (see the Streambed Sediment section) can also degrade the floodplain complex (Poole and Berman in prep).

<u>Water Quantity in the Hoh Basin</u>

The mainstem and South Fork Hoh Rivers are glacier-fed. While peak flows occur in November and December, the average daily flows are greatest in June because of glacial melt (Ryan and Prigge in prep.). Low flows typically occur in August and September. The glacial melt also results in diurnal changes that create dynamic flows and channel patterns. A change has been noticed in the glacial melt to the South Fork Hoh. About 7-8 years ago, the glacial influence greatly decreased in the South Fork Hoh, which is likely resulting in lower flows and more vulnerable conditions for spring chinook (Dick Goin, personal communication).

The trend of peak flows has increased from the 1960s, but when that increase is corrected for precipitation levels, there is no significant difference between the current and historic (1960s) peak flows. Precipitation levels are expected to be higher in the near future due to a probable switch in the Pacific Decadal Oscillation (Mantua 1997). These climate shifts occur every 20-30 years, and scientists believe that we have just switched from a warmer, drier regime to a wetter, cooler phase.

Road density not only correlates to an increase in debris flows within the Hoh basin, but the volume of mid-slope roads correlates with increases in peak flows (John McMillan, Hoh Tribe, personal communication). La Marche and Lettenmaier (1998) reported a similar relationship between road hillslope position and peak flows in four other drainages. The effects of roads on increased flow is independent of quantity of forest harvest, but when both activities are combined, the model developed by La Marche and Lettenmaier (1998) showed an increase in 10-year return floods of 21%.

The middle Hoh has high percentages of watersheds that are hydrologically immature (<30 years old). The levels of hydrologic immaturity are: Braden (79%), Anderson (67%), Nolan (64%), Elk (61%), Owl (58%), Alder and Winfield (55%), Willoughby (54%), Lost (46%) and Pins (43%) Creeks (Cederholm and Scarlett 1997). Levels at or above 60% are rated "poor" for water quantity (see Assessment Chapter for details), which results in "poor" ratings for Braden, Anderson, Nolan, and Elk Creeks. The vegetation loss contributes to peak flows, and can also increase the effects of roads on peak flows by increasing the volume of sub-surface flow intercepted by the cutslopes (La Marche and Lettenmaier 1998).

The loss of vegetation has thought to decrease the aquifer and wetland storage capacity by disconnecting the wetland hydrologic continuity and altering upland water infiltration and groundwater recharge (Poole and Berman in prep.). Increased sediment delivery (see the Streambed Sediment section) has widened and reduced the depth of many stream channels, worsening the impacts of altered stream flow.

Tributaries in the Hoh basin frequently go subsurface in their headwaters, some of which may have naturally occurred, but to what degree is unknown. In upper Winfield Creek, a large quantity of salmonids died in the summer of 1999 because of low flow, low dissolved oxygen and high water temperatures (all interrelated problems) (John McMillan, Hoh Tribe, personal communication). This problem would be lessened by the presence of thermal refuges such as deep pools.

Another potential impact on summer low flows is the loss of large trees that can collect fog drip. Large trees collect moisture from fog, especially Sitka spruce zones (U.S. Forest Service 1995). Fog drip contributed an estimated 35% of the annual precipitation under the old growth canopy (Norse, 1990). The potential effect of vegetation loss on fog drip and decreased summer stream flows is a data need.

Low flow measurements aren't currently available, but summer low flows in the Goodman Creek mainstem have been identified as a concern (Phinney and Bucknell 1975). The Goodman Creek basin contains a high density of wetlands, indicating high ground waters inputs (Jill Silver, Hoh Tribe, personal communication).

Biological Processes in the Hoh Basin

The Hoh sub-basin rated "poor" for biological processes, although using the criteria in the Assessment Chapter, nutrient cycling rated "good". Escapement goals for fall chinook, spring/summer chinook, and winter steelhead are often met (McHenry et al. 1996). In recent years, fall coho escapement has declined and this is a concern. Also, levels of fall chum have declined compared to the past, but no escapement goals have been established for this stock.

The "poor" rating is the result of other problems. One is a reduced level of macroinvertebrates in areas impacted by spalts. Macroinvertebrates serve as food for juvenile salmonids. The areas of impact are in the Hoh, Steamboat, and Cedar basins. Specific locations are listed in the access section for the Hoh basin.

Another problem is the decline of beaver populations. Beaver ponds supplement summer low flows and provide over-wintering habitat for salmonids. The ponds fill with sediments, creating wetlands to support macroinvertebrates. They also trap nutrients that contribute to ecosystem function.

Estuary and Near Shore Conditions for WRIA 20

The north coast of Washington State is characterized by rugged headlands (such as Cape Flattery, Cape Alava, and Hoh Head) and cliffs separated by pocket beaches. In contrast to the sandy beaches along the south coast of Washington, the habitat north of Point Grenville is a mix of rock, gravel, and sand. The pocket beaches lie in a more protected environment than the southern coast beaches. Because of that, there are less substrate shifts and more organic materials in the sand (U.S. Dept. Commerce 1993). In protected coves such as Cape Alava and Cedar Creek, boulder and cobble comprise the substrate (Figure 10). These support a greater diversity of organisms compared to the sandy substrates to the south.

The Olympic Coast National Sanctuary is located within the near shore habitat of this WRIA. It encompasses 2500 square nautical miles from the U.S./Canada boundary south to the southern boundary of the Copalis National Wildlife Refuge, and extends about 30-40 miles offshore.

The near shore area is influenced by the Columbia River. The Columbia River outflow forms a low-salinity plume that extends along the Washington coast in the winter. In the summer, the plume is directed to the south by changing currents. The same currents shift sand northward in the winter months and southward in the summer (US Dept. Commerce 1993). Sediments from the Columbia River have been important for beach maintenance, particularly in those areas from the Hoh River mouth south. This sediment supply has decreased by 24-50% due to dams in the Snake and Columbia River basins (WA DNR 1999). This is likely a major problem for the near shore environment.

Figure 10. The small protected cove near Cedar Creek with a large seastack.

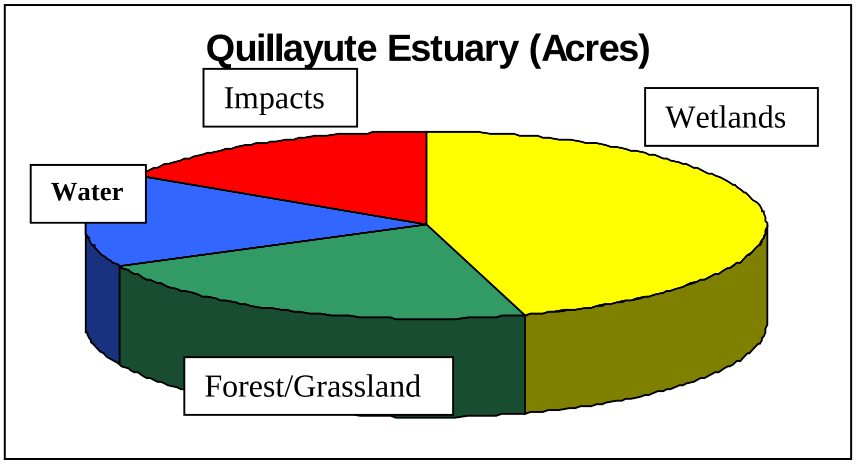
The continental shelf off the north Washington coast is ranked high for biological productivity due to upwelling (Strickland and Chasan 1989). Upwelling occurs when nutrients from the bottom are brought up to the area of water exposed to sunlight. This increases plant production, especially from the single-celled plants (phytoplankton). Upwelling is greater in the spring and summer months, less in the fall, and low in winter.

The north coast also supports the highest density of kelp in the world (Dayton 1985). These are located mostly along the mudflats and rocky shores. The kelp provides critical habitat for salmonids and contributes to the foodweb that salmon depend upon. The most dominant canopy-forming kelp in this area are bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis integrifolia*) (Simenstad et al 1988). The kelp beds within the Olympic Coast National Sanctuary represent 34% of the total Washington State kelp resource, and quantities of kelp in the area have remained fairly stable in recent years (Van Wagenen 1998). The understory kelp includes a variety of algae, and contributes to habitat structure and the foodweb. These habitats support salmonid stocks from Washington, Oregon, California, and British Columbia (U.S. Dept. Commerce 1993).

The estuaries in WRIA 20 are small and isolated. In the estuaries, eelgrass provides important habitat and ecological functions for salmonids as well (Strickland and Chasan 1989). Eelgrass prefers soft sandy or muddy bottoms. It helps stabilize sediments, minimizes erosion, and provides nursery habitat for juvenile salmonids. Eelgrass also supports surf smelt and sand lance, which are important food items for salmonids.

The largest estuary in WRIA 20 is the Quillayute estuary. In a 1979 inventory, the categories of lands and landuse in the estuarine area were assessed (Figure 11) (ACOE 1979). The open water estuary covered 71 acres, while wetlands accounted for 198 acres. Impacted areas covered 70 acres and included commercial, residential, transportation/utility use, marine development, the breakwater, and dredged/filled areas. Upland forest and grasslands accounted for 98 acres. The loss of habitat as measured over 20 years ago, was about 19% of the estuarine lands.

Figure 11. Acres of Land Type in the Quillayute Estuary (ACOE 1979).



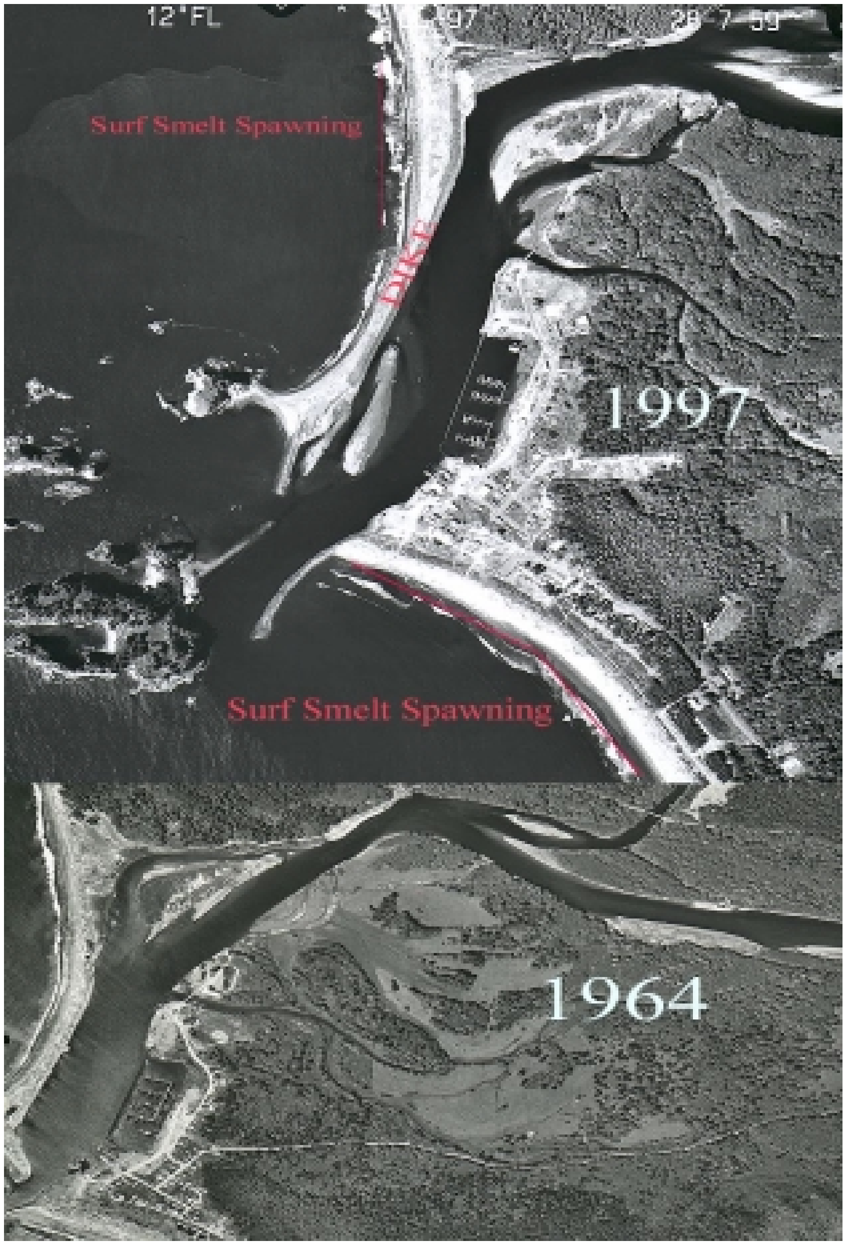
The mouth of the Quillayute River has changed substantially in the last several decades. Some of the change has been attributed to migration of beach sediments (Rau 1980). However, much of the change is the result of direct habitat modifications. The Army Corps of Engineers maintains a navigational channel in the lower Quillayute River, as well as a protective jetty and a boat basin (Figure 12). The jetty and dike were constructed in 1931, and dredging began in 1949 (Chitwood 1981). The boat basin was dredged in 1957. Both the channel and boat basin have required regular dredging every 2-3 years (Chitwood 1981). In addition, more protective structures have been added to the banks of the lower river. The dredging coupled with the dike and other protective structures have formed a deep channel that speeds the flow of water. This forms a poor environment for salmonids, reducing spawning and winter refuge habitat by disconnecting the river from its historic floodplain and increasing substrate instability.

The extent of modifications of the lower river is considerable, and rates “poor” for this assessment. Figure 12 shows the dike, jetty and boat basin, as well as a major change in the river from 1964 to 1997. In recent years, the main channel has changed places with Quillayute Slough, just upstream of the dike.

Upland changes also impact the estuarine habitat. The vast majority of land use is forestry (94%), and sedimentation has been identified as a major habitat problem in all of the sub-basins. Sediment loads are transported downstream, and there is concern that increased sedimentation to the estuary and near shore environment is reducing the eelgrass and kelp habitat.

There is also concern that Rialto Beach (located adjacent and north of the Quillayute spit) is receding, but data are needed to assess this concern (Wullschleger 1999). Rialto Beach is used by surf smelt for spawning and would provide an important food resource for salmonids. Surf smelt spawning has also been documented on the beach just south of the Quillayute River mouth (Figure 12).

Figure 12. Quillayute Estuary (1997 & 1964).



The Quillayute estuary is used by chinook salmon juveniles year round with peaks from May through September (Chitwood 1981). Other salmonid species also use this estuary as well as the other smaller estuaries in WRIA 20. The near shore habitat throughout WRIA 20 was rated as "very significant" for chinook, coho, and sockeye salmon and steelhead trout in this region, and was rated "significant" for chum salmon (U.S. Dept. Commerce 1993).

Sediment impacts to the other small estuaries and the lowest reaches of mainstems are highly likely due to the upstream sedimentation problems. The mouth of the Hoh River changes frequently. Figure 13 shows the lower river mainstem at three points in time, with changes in sinuosity and at the mouth itself. The area was examined at several other points in time between the years shown and changes occurred with every photograph examined. While this area is probably naturally unstable, channel changes at the mouth of the Hoh River seemed to increase about 35 years ago (Dick Goin, personal communication). Research on the impacts of sediment transport is a high priority data need for the estuaries in WRIA 20.

The Ozette River estuary has changed considerably in the last century (Figure 14). In the 1950s, a spit began to form near the mouth of the river, and by 1971, the spit has constricted the river mouth. In 1997, the spit has become permanent enough to support the growth of beach rye and accumulated stable LWD (Figure 14). There appears to be a loss of tidal energy based upon examination of small tidal channels that were formed under previously higher tidal energy, but are now filling with small debris that is no longer moved by the current, lower tidal energy (Joel Freudenthal, Clallam County, personal communication). The former tidal flux would have been on the order of 12 feet (plus storm surge) based on the elevation of the bedrock control at the river mouth. This compares to a current flux of around 18 inches to 2' (Joel Freudenthal, Clallam County, personal communication). Another result of lower tidal energy is the accumulation of tannic acids within the estuary. In many locations, the bottom of the Ozette estuary cannot be seen due to the darkness of the water. One possible explanation for the change in tidal energy and spit development is a change in the natural hydrologic conditions within the river and the lake. The removal of LWD from Ozette River may have altered the degree and timing of water level fluctuations in the lake (Joel Freudenthal, Clallam County, personal communication).

Water quality has not been extensively monitored in the estuaries and near shore environments of WRIA 20, and this remains a data need. However, low dissolved oxygen levels were measured in the Quillayute boat basin about 20 years ago (Chitwood 1981). This was thought to be due to waste dumping from boats coupled with the lack of flushing of estuary water. However, it is unknown whether or not this is a current problem. The small estuary at the mouth of Goodman Creek is thought to be important salmonid habitat. Water quality and salmonid use should be monitored in this rare habitat.

In general, pollution from traditional sources (wastewater, industry, urban run-off) are thought to be low (U.S. Dept. Commerce 1993). However, low levels of radionuclides and higher levels of polynuclear aromatic hydrocarbons have been found in sediments on the continental shelf between the Columbia River and Quinault Canyon (near the Hoh River mouth) (Horner 1996). The source of these contaminants is the aluminum smelters on the lower Columbia River. Pesticide use is very low compared to other West Coast areas (U.S. Dept Commerce 1993).

Figure 13. Channel changes in the lower Hoh River.

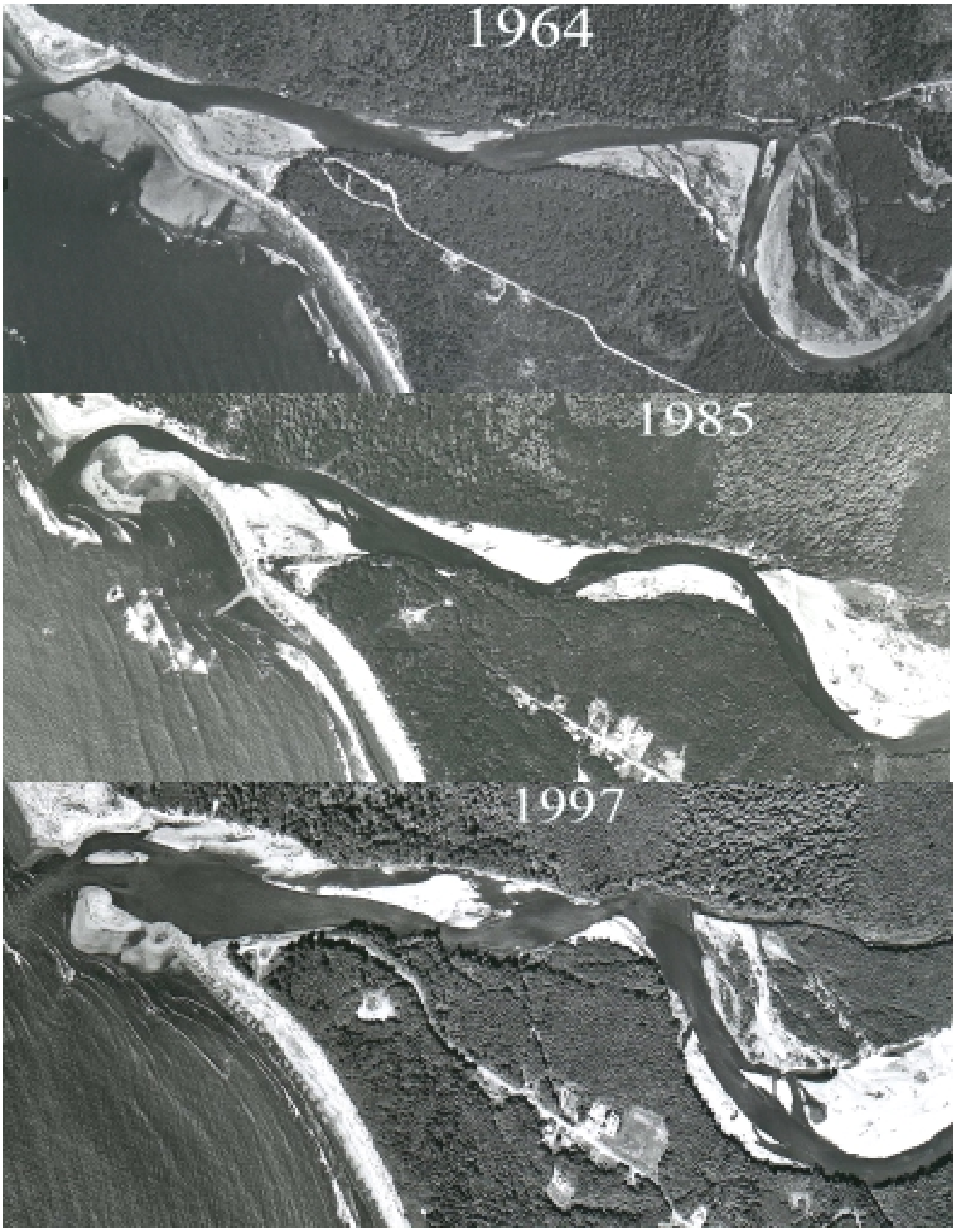
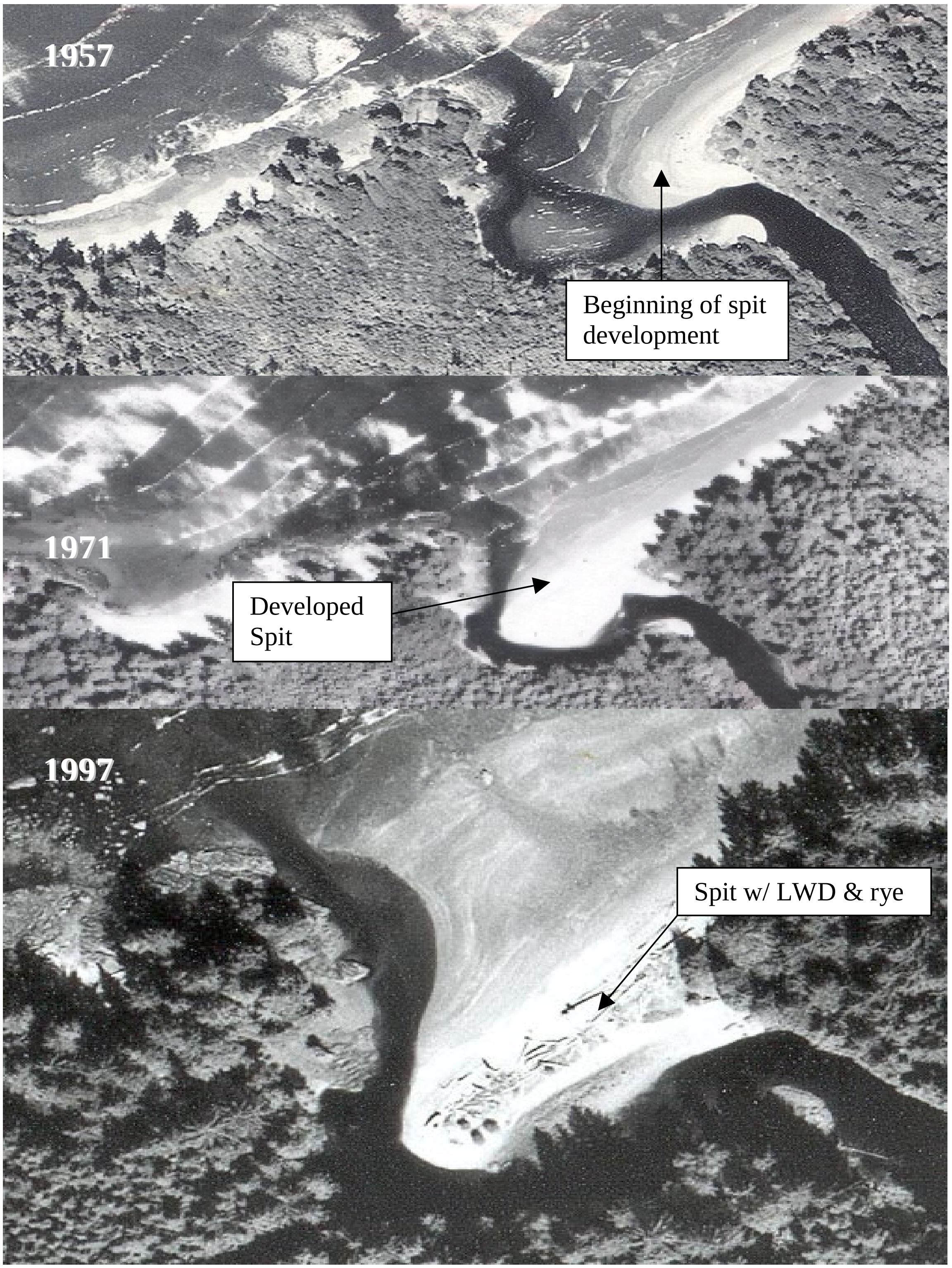


Figure 14. Changes over time in the lower Ozette River.



ASSESSMENT OF HABITAT LIMITING FACTORS

Under the Salmon Recovery Act (passed by the legislature as House Bill 2496 and later revised by Senate Bill 5595), the Washington Conservation Commission (WCC) is charged with identifying the habitat factors limiting the production of salmonids throughout most of the state. This information should guide lead entity groups and the Salmon Recovery Funding board in prioritizing salmonid habitat restoration and protection projects seeking state and federal funds. To provide the best guidance possible, current, known habitat conditions were identified and rated. Rating habitat limiting factors requires a set of standards that can be used to compare the significance of different factors and consistently evaluate habitat conditions in each WRIA throughout the state.

To develop a set of standards to rate salmonid habitat conditions, several tribal, state, and federal documents that use some type of habitat rating system (Table 13) were reviewed. The goal was to identify appropriate rating standards for as many types of habitat limiting factors as possible, with an emphasis on those that could be applied to readily available data. Based on the review, it was decided to rate habitat conditions into three categories: “good”, “fair”, and “poor”. For habitat factors that had wide agreement on how to rate habitat condition, the accepted standard was adopted by the WCC. For factors that had a range of standards, one or more of them were adopted. Where no standard could be found, a default rating standard was developed, with the expectation that it will be modified or replaced as better data become available.

The ratings adopted by the WCC are presented in Tables 14-15. These ratings are not intended to be used as thresholds for regulatory purposes, but as a coarse screen to identify the most significant habitat limiting factors in a WRIA. They also will hopefully provide a level of consistency between WRIAs that allows habitat conditions to be compared across the state. However, for many habitat factors, there may not be sufficient data available to use a rating standard or there may be data on habitat parameters where no rating standard is provided. For these factors, the professional judgement of the TAG should be used to assign the appropriate ratings. In some cases there may be local conditions that warrant deviation from the rating standards presented here. This is acceptable as long as the justification and a description of the procedures used are clearly documented in the limiting factors report.

A summary of the habitat conditions for WRIA 20 is presented in Table 16. These represent generalized conditions within that stream. There are likely some reaches of the stream that will be better or worse condition than the rating suggests. In many cases, insufficient data and knowledge about the conditions was found. For those instances, the rating is left blank. The conditions are based upon the standards in Tables 14-15, and are described in more detail in the Habitat Limiting Factors Chapter. In the following chapter, recommendations and data needs are described in more detail.

Table 13. Source documents for the development of standards.

Code	Document	Organization
WSP	Wild Salmonid Policy (1997)	Washington Department of Fish and Wildlife
PHS	Priority Habitat Management Recommendations: Riparian (1995)	Washington Department of Fish and Wildlife
WSA	Watershed Analysis Manual, v4.0 (1997)	Washington Forest Practices Board
NMFS	Coastal Salmon Conservation: Working Guidance (1996)	National Marine Fisheries Service
Skagit	Skagit Watershed Council Habitat Protection and Restoration Strategy (1998)	Skagit Watershed Council
Hood Canal	Hood Canal/Eastern Strait of Juan de Fuca Summer Chum Habitat Recovery Plan (1999)	Point No Point Treaty Council and Washington Department of Fish and Wildlife

Table 14. Salmonid habitat condition standards.

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Access and Passage						
Artificial Barriers	% known/potential habitat blocked by artificial barriers	All	>20%	10-20%	<10%	WCC
Floodplains						
Floodplain Connectivity	Stream and off-channel habitat length with lost floodplain connectivity due to incision, roads, dikes, flood protection, or other	<1% gradient	>50%	10-50%	<10%	WCC
Loss of Floodplain Habitat	Lost wetted area	<1% gradient	>66%	33-66%	<33%	WCC
Channel Conditions						
Fine Sediment	Fines < 0.85 mm in spawning gravel	All – Westside	>17%	11-17%	≤11%	WSP/WSA/ NMFS/Hood Canal
	Fines < 0.85 mm in spawning gravel	All – Eastside	>20%	11-20%	≤11%	NMFS

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Large Woody Debris	pieces/m channel length	≤4% gradient, <15 m wide (Westside only)	<0.2	0.2-0.4	>0.4	Hood Canal/Skagit
	or use Watershed Analysis piece and key piece standards listed below when data are available					
	pieces/channel width	<20 m wide	<1	1-2	2-4	WSP/WSA
	key pieces/channel width*	<10 m wide (Westside only)	<0.15	0.15-0.30	>0.30	WSP/WSA
	key pieces/channel width*	10-20 m wide (Westside only)	<0.20	0.20-0.50	>0.50	WSP/WSA
	* Minimum size to qualify as a key piece:	BFW (m)	Diameter (m)	Length (m)		
		0-5	0.4	8		
		6-10	0.55	10		
		11-15	0.65	18		
		16-20	0.7	24		
Percent Pool	% pool, by surface area	<2% gradient, <15 m wide	<40%	40-55%	>55%	WSP/WSA
	% pool, by surface area	2-5% gradient, <15 m wide	<30%	30-40%	>40%	WSP/WSA
	% pool, by surface area	>5% gradient, <15 m wide	<20%	20-30%	>30%	WSP/WSA
	% pool, by surface area	>15 m	<35%	35-50%	>50%	Hood Canal
Pool Frequency	channel widths per pool	<15 m	>4	2-4	<2	WSP/WSA

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
	channel widths per pool	>15 m	-	-	chann width / pools/ mile / cw/ pool 50’ 26 4.1 75’ 23 3.1 100’ 18 2.9	NMFS
Pool Quality	pools >1 m deep with good cover and cool water	All	No deep pools and inadequate cover or temperature, major reduction of pool volume by sediment	Few deep pools or inadequate cover or temperature, moderate reduction of pool volume by sediment	Sufficient deep pools	NMFS/WSP/ WSA
Streambank Stability	% of banks not actively eroding	All	<80% stable	80-90% stable	>90% stable	NMFS/WSP
Sediment Input						
Sediment Supply	$m^3/km^2/yr$	All	> 100 or exceeds natural rate*	-	< 100 or does not exceed natural rate*	Skagit
	* Note: this rate is highly variable in natural conditions					
Mass Wasting		All	Significant increase over natural levels for mass wasting events that deliver to stream	-	No increase over natural levels for mass wasting events that deliver to stream	WSA
Road Density	mi/mi^2	All	>3 with many valley bottom roads	2-3 with some valley bottom roads	<2 with no valley bottom roads	NMFS
	or use results from Watershed Analysis where available					

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Riparian Zones						
Riparian Condition	• riparian buffer width (measured out horizontally from the channel migration zone on each side of the stream) • riparian composition	Type 1-3 and untyped salmonid streams >5' wide	• <75' or <50% of site potential tree height (whichever is greater) OR • Dominated by hardwoods, shrubs, or non-native species (<30% conifer) unless these species were dominant historically.	• 75'-150' or 50-100% of site potential tree height (whichever is greater) AND • Dominated by conifers or a mix of conifers and hardwoods (≥30% conifer) of any age unless hardwoods were dominant historically.	• >150' or site potential tree height (whichever is greater) AND • Dominated by mature conifers (≥70% conifer) unless hardwoods were dominant historically	WCC/WSP
	• buffer width • riparian composition	Type 4 and untyped perennial streams <5' wide	<50' with same composition as above	50'-100' with same composition as above	>100' with same composition as above	WCC/WSP
	• buffer width • riparian composition	Type 5 and all other untyped streams	<25' with same composition as above	25'-50' with same composition as above	>50' with same composition as above	WCC/WSP

Habitat Factor	Parameter/Unit	Channel Type	Poor	Fair	Good	Source
Water Quality						
Temperature	degrees Celsius	All	>15.6° C (spawning) >17.8° C (migration and rearing)	14-15.6° C (spawning) 14-17.8° C (migration and rearing)	10-14° C	NMFS
Dissolved Oxygen	mg/L	All	<6	6-8	>8	ManTech
Hydrology						
Flow	hydrologic maturity	All	<60% of watershed with forest stands aged 25 years or more	-	>60% of watershed with forest stands aged 25 years or more	WSP/Hood Canal
		or use results from Watershed Analysis where available				
	% impervious surface	Lowland basins	>10%	3-10%	≤3%	Skagit
Biological Processes						
Nutrients (Carcasses)	Number of stocks meeting escapement goals	All Anadromous	Most stocks do not reach escapement goals each year	Approximately half the stocks reach escapement goals each year	Most stocks reach escapement goals each year	WCC
Lakes (further work needed)						
Estuaries – See Table 3 Below						

Table 15. System for rating estuarine habitat conditions

Rating of Estuarine Habitat Conditions									
All Values are Referenced to Historic Conditions of Estuary which is defined as both wetted and upland area.									
The following system can be applied for both large and small estuaries.									
Large Estuaries are defined as an estuary where the area of Zone 1 and 2 combined is greater than approximately 2.0 sq miles									
For large estuaries, treat zone 1, 2 and 3 seperately. For small estuaries, treat zone 1 and 2 as one area combined.									
	Zone Characteristics	Parameter	Poor		Fair		Good		
Upper	FW tidal to brackish marsh area.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Carex.	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	Ranges down to where Fucus and	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	Salnicornia become prevelant and	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.
	Carex is sparse.								
		Aquatic Conditions							
		1- % Historic Marsh Remaining	< 25%	2	25-50%	6	> 50%	10	Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2	25-50%	6	< 25%	10	Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2	25-50%	6	< 25%	10	Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2	25-50%	6	< 25%	10	Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2	10-25%	6	< 10%	10	Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)							
		Only one score depending on whether there has	> 50%	2	10-50%	6	<10%	10	% Reduction in Average Annual Flow
		been a net increase or decrease			OR				
			> 50%	2	10-50%	6	<10%	10	% Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns	Large	2	Medium	6	High	10	Subjective rating
		8- Water quality (Subjective)	Poor	2	Fair	6	Good	10	Subjective rating
		Overall Zone Rating							
		Good	73-100						
		Fair	48-72						
		Poor	20-47						
Lower	Brackish Marsh to delta face.	**Upland Condition**							
	Zone is delineated mostly by vegetatio	1- % Developed lands (Non Agricultural, Non Vegetate	> 50%	1	25-50%	3	< 25%	5	Within historic estuary area.
	Dominant vegetation type is Fucus	2- % Agricultural lands	> 75%	1	50-75%	3	< 50%	5	
	and Salnicornia. Zone stops along	3- % Forested uplands	< 25%	1	25-50%	3	> 50%	5	
	shore where these marsh plant stops.	4- % Historic Floodplain Wetlands Remaining	< 25%	1	25-50%	3	> 50%	5	Mostly unconnected, non marsh areas.

		Aquatic Conditions							
		1- % Historic Marsh Remaining	< 25%	2	25-50%	6	> 50%	10	Marsh only
		2- % Mainstem Channel Habitat Lost	> 50%	2	25-50%	6	< 25%	10	Reflects loss of sinuosity
		3- % Non-Mainstem Habitat Lost	> 75%	2	25-50%	6	< 25%	10	Sloughs, off channel areas
		4- % Estuary Disconnected From Floodplain	> 75%	2	25-50%	6	< 25%	10	Disconnected from floodplain
		5- % Covered by Aquatic Exotic Plants	> 25%	2	10-25%	6	< 10%	10	Primarily Spartina
		6- Hydrology (Amount of Water Arriving In Estuary)							
		Only one score depending on whether there has	> 50%	2	10-50%	6	< 10%	10	% Reduction in Average Annual Flow
		been a net increase or decrease			OR				
			> 50%	2	10-50%	6	< 10%	10	% Increase in Average Annual Flow
		7- Hydrology (% Deviation From Natural Flow Patterns)	Large	2	Medium	6	High	10	Subjective rating
		8- Water quality (Subjective)	Poor	2	Fair	6	Good	10	Subjective rating
		Overall Zone Rating							
		Good	73-100						
		Fair	48-72						
		Poor	20-47						
Nearshore	Zone bounded by the edge of the delta	% Diked or Bulkheaded	> 66%	2	33-66%	6	< 33%	10	
Marine	to the boundary of the photic zone and	Docks/km of Shoreline	> 10	1	4 to 9	3	< 4	5	
	continuing along the shore to a point	% Intact Riparian Zone	< 25%	1	25-50%	3	> 50%	5	Defined as within 100 ft of MLLW
	halfway to the next estuary.	% Covered by Exotic Aquatic Plants	> 25%	1	10-25%	3	< 10%	5	
		Overall Zone Rating							
		Good	19 to 25						
		Fair	12 to 18						
		Poor	5 to 11						
			Small		**Large**				In small estuaries zones 1 and 2
		Overall Estuary Rating							are combined into a single score.
		Good	**92-125**		**164 to 225**				
		Fair	**60-91**		**107 to 163**				
		Poor	**25-59**		**65 to 106**				
Notes:	See Summer Chum Report from Hood Canal								
	Consider this a first order approximation								
	Vegetation zones will need to be more precisely defined but they should be more or less delineated in a field day.								
	All area calculations should be based upon the historically defined estuarine area and its associated floodplain.								
	Reveted and levees may be correlated with mainstem and off channel habitat lost.								
	One problem is that this is weighed heavily in favor of the marsh part of the estuary. The nearshore is diminished in importance. Will need to weigh this somehow.								

Table 16. Summary of WRIA 20 Limiting Factors Results

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes
Waatch Basin:	Poor												Poor
Waatch R.		Fair								Poor			
Educket Cr.										Poor			
Sooes Basin:	Fair												Poor
Sooes R.										Poor			
Snag Cr.		Poor											
Thirty Cent Cr	Poor	Poor											
Ozette Basin:	Fair											Poor	Poor
Ozette R.							Poor	Good		Poor			
Lake Ozette					Poor					Fair			Poor
Coal Cr.		Poor								Poor			
Umbrella Cr.		Poor		Poor	Poor			Poor		Poor	Poor		
Big R.		Poor		Poor	Poor		Poor-Good	Poor-Fair		Poor	Good		

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes
Solberg Cr.		Poor											
Trout Cr.					Fair								
Boe Cr.	Poor	Fair			Fair								
Crooked Cr.					Fair-Poor		Good	Poor-Fair		Poor	Good		
NF Crooked					Poor		Good	Good			Good		
SF Crooked					Poor		Poor-Good	Fair-Good			Poor		
Siwash Cr.					Poor		Poor				Poor		
South Cr.		Poor			Poor-Good		Fair-Good	Poor-Good					
Quillayute Basin:													Good
Dickey Sub Basin	Poor									Poor	Poor		
Coal Cr.		Fair								Poor			
Colby Cr.		Poor											
WF Dickey			Good (lower ms)		Poor	Fair	Fair-Good	Poor (wind-throw)	Poor	Poor			

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes
Squaw Cr.			Poor		Poor		Good	Good	Good	Poor			
Ponds Cr.	Poor		Good		Poor		Poor	Poor-Good	Good				
Stampede Cr.			Good		Poor		Good	Poor	Good				
MF Dickey			Poor		Poor	Good	Good	Poor	Good	Poor			
EF Dickey			Poor		Poor	Fair	Poor	Poor	Poor	Poor			
Thunder Cr.			Poor		Poor in tribs		Poor	Good; Poor in lower	Good (Fair-Poor in tribs)	Poor			
Skunk Cr.			Good		Poor		Good	Poor-Good	Poor	Poor			
Gunderson Cr.	Poor		Poor		Poor		Good	Poor	Good				

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes
Soleduck Sub-Basin											Poor in lower -mid		
Soleduck River		Fair		Fair		Fair		Poor-Fair; Good in head-waters	Good	Poor in lower and middle ms			
Tassel Cr.	Poor				Fair		Poor	Poor in lower	Good		Good		
Shuwah Cr.		Poor			Poor	Poor	Poor		Poor		Good		
Gunderson Cr.	Poor			Fair	Poor		Poor	Poor in lower	Good in lower				
Swanson Cr.										Poor			
Bockman Cr.				Poor	Poor		Poor	Poor	Fair		Good		
Lake Cr.				Poor	Poor in upper; Fair-lower	Poor	Poor	Poor-Fair	Good	Poor	Poor		
Beaver Cr.					Poor	Poor	Poor	Poor	Poor	Poor	Poor		

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes
Bear Cr.		Poor		Fair-Good	Poor; Good in South Bear	Poor	Poor	Poor-Fair	Poor lower Good upper	Poor	Poor		
Kugel Cr.		Poor		Fair	Poor		Poor	Poor	Poor		Poor		
Camp Cr.		Poor		Poor	Poor		Poor	Poor	Poor		Poor		
Goodman Cr.				Poor	Fair		Fair	Good	Good	Poor	Poor		
Alckee Cr.				Good	Good		Good	Good	Good		Good		
SF Soleduck		Fair		Poor lower Good in upper	Poor		Fair	Fair-Good	Fair		Poor		
NF Soleduck		Fair		Good	Good		Good	Good	Good		Good		
Bogachiel Sub-Basin													
Bogachiel R.		Poor lower; Good upper	Poor lower; Good upper		Poor-lower	Poor-lower	Poor lower; Good upper	Poor lower; Good upper		Poor in lower			
Grader Cr.	Good												
Mill Cr.		Fair											

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes	Near Shore
Hemp Hill Cr.		Poor												
Calawah Sub-Basin														
Calawah River														
NF Calawah R.		Poor	Poor	Poor in head-waters	Fair	Poor	Poor	Fair	Poor-Fair	Good	Good			
Cool Cr.		Poor	Poor		Fair			Poor in Western; Good in Eastern	Fair West; Poor East	Good	Good			
Devils Cr.		Poor				Fair	Good	Poor in lower	Fair	Good	Good			

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes	Near Shore
Albion Cr.			Poor		Poor	Poor	Fair		Fair-Poor	Poor shade	Good			
Pistol Cr.			Poor			Poor	Good		Poor	Poor shade	Good			
SF Calawah R.		Fair	Poor	Poor ms		Poor	Poor	Good	Fair-Good		Good			
Hyas Cr.		Poor	Poor	Poor		Poor	Poor	Fair	Good	Poor	Poor			
Sitkum R.		Fair	Poor	Poor		Poor	Poor	Fair-Good	Fair-Good	Poor	Poor			
Goodman Cr.			Poor in middle			Poor in middle	Poor in middle	Poor in middle	Poor in mid					
Hoh Basin													Poor	
Hoh River		Poor	Poor in middle Hoh			Poor	Poor in lower; Good in upper	Poor in lower; Good in upper						
Braden Cr.			Poor	Good	Fair		Poor	Poor	Good	Poor	Poor			
Nolan Cr.	Poor	Fair	Poor	Fair			Poor	Poor	Fair	Poor	Poor			
Anderson Cr.			Poor	Good	Fair		Poor	Good	Poor	Poor	Poor			

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes	Near Shore
Lost Cr.			Poor	Good			Poor	Good	Good	Poor	Good			
Winfield Cr.		Fair	Poor	Good			Poor	Poor	Fair	Poor	Poor			
Hell Roaring Cr.	Poor	Poor in EF					Poor-Good	Good						
Alder Cr.	Poor	Poor	Poor	Fair	Fair	Poor	Poor	Fair-Good	Fair	Poor	Good			
Elk Cr.				Fair	Fair		Poor	Poor	Good	Poor	Poor			
Willoughby Cr.			Poor	Fair		Poor	Fair-Poor	Poor	Poor	Poor	Good			
Clear Cr.	Poor		Poor					Poor		Poor				
Pins Cr.			Poor	Fair			Poor	Poor	Good	Poor	Good			
Dry Cr.		Poor					Poor							
Spruce Cr.		Poor	Poor		Poor	Poor	Poor	Fair						
Canyon Cr.			Poor				Poor	Fair		Poor				
Owl Cr.		Poor	Poor	Fair		Poor	Poor	Good	Poor	Poor	Good			
Maple Cr.		Poor					Poor	Poor		Poor				

Stream Name	Access	Flood-plain	Sediment Quantity	Sediment Road Density	Sediment Quality, Fines	Channel Stability	Instream LWD	Riparian	Pools	Water Quality	Flows	Estuary	Biological Processes	Near Shore
Jackson Cr.							Good	Good						
Mount Tom Cr.		Fair					Good	Good						
SF Hoh River		Fair					Poor in lower; Good in upper	Fair in lower; Good in upper		Lower tribs are Poor				
Cedar Cr.	Poor		Poor					Poor						
Steamboat Cr.	Poor	Fair	Poor					Poor						

HABITAT IN NEED OF PROTECTION

Recommendations

<u>Hoh Basin:</u>

The Hoh basin has naturally abundant river-floodplain bottom areas, which have channel complexes that intercept wall-based spring-fed channels, valley-wall, and terrace tributaries. These are important, stable habitat, particularly as over-wintering habitat for coho salmon (Peterson and Reid 1984) (Map 7). They are less impacted than newer river meander channels by storm flows, and have abundant pool habitat, vegetation, and low gradients. The alluvial floodplain is also the site of significant exchange between nutrient rich groundwater and surface water, which leads to high levels of productivity in an unaltered system (Poole and Berman in prep.). Below is a prioritized list of floodplain complexes that need protection and conservation. They were prioritized based upon relative importance to coho production followed by chinook spawning (Jim Jorgensen, Hoh Tribe, personal communication). Separate priorities are given for areas downstream of the Olympic National Park and those within Park boundaries.

Downstream of the Olympic National Park (RM 29.9):

1) Elk Creek Floodplain, extensive side-channel complexes fed by springs, terrace tributaries and Elk Creek, a valley-wall tributary, left bank (looking downstream) immediately above the mouth of Winfield Creek (RM ~17-18.5.

2) Braden Creek Floodplain Side-Channel Complex fed by springs and Braden Creek, left bank near RM 3-4.5.

3) Nolan Creek River Bottom, extensive set of side-channels, spring-fed and terrace fed tributaries and ponds, one spring-fed channel is a recent WDFW project that reclaimed an old filled-in dry river swale by a major excavation, left bank, immediately above Nolan Creek extending approximately 1.5 miles upriver near RM 5-6.5.

4) Cottonwood Bottom, spring-fed pond channel, right bank near RM 12-12.9.

5) Domrud Pond, spring-fed pond channel, left bank at Peterson's property (RM~19).

6) Pins Creek Floodplain Bottom, ponded old river channel for lower 1.0 miles fed by Pins Creek, left bank tributary (RM ~7).

7) Anderson Reach River Bottom, extensive set of channels with furthest downstream being a WDFW habitat enhancement pond, right bank near RM 13.5-15.

8) Crippen Homestead/Bradenbarry Lots Floodplain, running from the junction of the North Fork and the South Fork Hoh downriver 1 mile. It begins as a terrace with an overflow and spring-fed channel 0.3 miles up the South Fork, continuing downriver to connect with a series of terrace and small valley-wall mainstem tributaries draining an area developed as recreational lots. This is located on the left bank near RM 29-30 on the mainstem Hoh River and up to RM 0.3 on the South Fork Hoh River.

9) Clear Creek and Young Slough River Bottom, protected spring-fed areas which provide habitat during higher flows. One 2000 foot channel reclaimed from dry channel swale by WDFW excavation, left bank near RM 22.9-24.5.

10) Lewis Channel complex, one main 1500 foot spring-fed channel reclaimed from dry channel swale under WDNR habitat project excavation, which is connected to other less protected spring-fed side-channels, right bank at RM 29-29.5.

11) Dismal Creek Pond River Bottom Complex, several terrace ponds plus a private timber company-owned gravel pit formed into an overwintering pond by WDFW, right bank near RM 26-27, between Spruce Canyon and Owl Creek.

Area on the South Fork of the Hoh River (a left bank tributary of the Hoh River at RM 30.0):

12) Lower South Fork complex, right bank for 1 mile above the bridge at RM 1.

Inside the Olympic National Park on the mainstem Hoh river above the South Fork confluence and on the South Fork Hoh above RM 3:

1) Taft Creek Floodplain, a spring-fed channel complex with a large pond at mouth, right bank near RM 35.3-36.3 of main Hoh River.

2) Big Flat, 4-5 spring-fed side-channel complexes, both banks near RM 6-9.5 on the South Fork Hoh.

3) Mt. Tom Springs, spring-fed channel complexes and a small pond, left bank at RM 38-38.5 on the main Hoh.

4) WRIA 20.0530 Creek, 1.5 mild side-channel fed by springs and a small valley-wall tributary, left bank near RM 47-48.5 of main Hoh.

5) Brocolli Side-Channel Complex, left bank near RM 42-43.5 of the main Hoh.

6) WRIA 20.0509 Creek, side-channel fed by valley-wall tributary and small wall-based side-channel, left bank near RM 32-32.5 of the main Hoh.

Soleduck Sub-Basin:

The Soleduck sub-basin is naturally limited in wetlands and off-channel habitat, and remaining wetlands should be protected. Of particular importance is off-channel habitat in: Gunderson Creek, Shuwah Creek, Lake Creek, Beaver Creek, and upper Bear Creek. Bear Creek is noted as special habitat because it supports the highest number of spawners/mile in the Soleduck Watershed.

Estuary and Marine Near Shore Habitat:

The marine near shore habitat is important for vast numbers of salmonid stocks (U.S. Dept. Commerce 1993), many of which originate from areas outside of WRIA 20. Kelp densities are high in the area (Dayton 1985), and conservation measures to protect this resource are important.

Estuarine habitat is also naturally very limited, and this type of habitat has been shown to be very important for salmonid juvenile rearing. Significant quantities of estuarine habitat has already been lost and degraded, and existing habitat should be protected and the upstream activities that degrade estuarine and near shore habitat should be a high priority restoration activity. Eelgrass beds are important for salmon rearing (Strickland and Chasan 1989), and particular concern should be placed on conservation of eelgrass areas. In addition, documented surf smelt spawning has occurred on Rialto Beach and on the beach south of the Quillayute River mouth. These areas should also be conserved. Goodman Creek has a small estuary that is recommended for protection as well.

RECOMMENDATIONS AND DATA GAPS FOR WRIA 20 HABITAT LIMITING FACTORS

Recommendations for Salmonid Habitat Restoration Actions in WRIA 20

The known, current salmon and steelhead habitat conditions for WRIA 20 have been identified and assessed as either “good”, “fair”, or “poor”. In addition, the impacts, sources of impact, and species impacted have been described, whenever possible in the Habitat Limiting Factors Chapter. Some of the major factors have also been mapped to show the extent of the conditions. Based upon this assessment, the following recommendations for habitat improvements and protection are listed by type of factor.

<u>Access</u>

- New structures should be sized to reflect expected increased flows. The next 20-30 cycle is expected to bring increased precipitation, which will lead to greater flows.

- Address blockages to salmon and steelhead habitat throughout WRIA 20, especially where “poor” ratings have been identified (see Assessment Chapter Table 4).

- Clean streams impacted by spalts, which not only prevent salmon from accessing habitat, but also degrade water quality and impact riparian habitat, macroinvertebrate production, and contribute to bank erosion. Streams impacted by spalts include Winfield Creek, Braden Creek, Clear Creek, Nolan Creek, and Red Creek in the Hoh basin. Other basins needing cleaning are Sand Creek, Steamboat Creek, and Cedar Creek.

<u>Floodplains</u>

- Floodplain habitat is especially important in the Hoh basin. Efforts to purchase intact floodplain habitat for conservation should be a high priority.

- Large wood within the floodplain should not be removed. Increase enforcement of current regulations is needed.

- Maintain and conserve off-channel habitat and associated riparian. More protection is needed for floodplain habitat, especially from development.

- Reduced beaver activity impacts rearing habitat. Beaver populations should not be further impacted.

- LWD should be increased in “poor” rated areas to allow sediments to accumulate for reconnection of incised channels to their floodplain.

- Reduce riparian roads (the best option for salmon), or at least reduce their impacts by improving surfacing materials.

Streambed and Sediment Issues

- LWD should be increased in “poor” rated areas, and in the Hoh and Bogachiel off-channel habitat where clay seams have been accessed by channel incision.

- Increase road drainage and route road sediments to the forest floor rather than to stream channels.

- Decommission side-cast roads.

- Improve road surfacing to reduce sediment inputs into streams.

Riparian

- Revegetate open riparian areas with native plants, including conifer.

- Banks should be disturbed as little as possible to avoid disruption of macroinvertebrate populations.

- Increased protection to riparian areas prone to windthrow is greatly needed. Current windthrow data specific to the north coastal streams should be used to guide harvest in these areas.

- Although new forestry regulations will provide much better conditions, riparian areas that have already been degraded need to be restored.

- Riparian surrounding wetlands should be protected to insure ground water recharge.

Water Quality

- Increase instream LWD to aid in nutrient cycling (salmonid carcass capturing) and pool development.

- Improve riparian conditions to increase shade and decrease current high summer water temperatures. Riparian conditions around wetlands should be restored and protected. This will help maintain lower water temperatures for water that will recharge streams.

- Water quality problems need to be addressed in Lake Creek. This stream is important for salmon habitat, but is impacted by residential development, failing septic systems, water withdrawals, and other human impacts.

- Address sediment sources to reduce channel widening and higher water temperatures.

<u>Water Quantity</u>

- The water velocity in the Quillayute River needs to be reduced in peak flow events, and the TAG recommends using an engineered natural model to reduce water velocity.

- Examine ways to reduce water rights within the Soleduck basin.

<u>Estuary and Near Shore</u>

- Protect surf smelt spawning areas (near the mouth of the Quillayute River).

- Reduce bank armoring in the lower reaches of the rivers and in the estuaries.

- Estuarine habitat is naturally very limited in WRIA 20. Current estuary habitat should be protected against dredging, filling, contaminants, and other impacts.

Data Needs for Salmonid Habitat Assessments in WRIA 20

This report was limited in its ability to clarify and prioritize impacts because of key data gaps. The following is a list of data needs that have been identified by the TAG. These data would greatly aid in developing effective recovery plans and to monitor the effectiveness of salmon habitat projects. The studies will also help better identify habitat limiting factors for salmonid production in the future.

<u>Fish Distribution and Stock Status</u>

- More complete salmon and trout distribution data are needed, especially for the Goodman basin. Adult and juvenile presence needs to be documented.

- Mapping and typing of all streams and wetlands in the Goodman Creek and Bogachiel basins is needed to identify where habitat protection is necessary.

- Potential distribution maps should be developed (maps showing where probable salmon and steelhead habitat is location).

- Stock trend information is needed for Sooes and Waatch coho and steelhead, Ozette steelhead, and Goodman and Mosquito Creek coho and steelhead.

- Measurements that link fish production to freshwater and estuary conditions.

Access

- Surveys for blockages to salmonids are needed for the Bogachiel and Calawah basins, as well as for Goodman and Cedar Creeks. Cedar Creek has been partially surveyed, and needs the private roads added.

- Surveys are also needed for the Hoh basin. It is estimated that only half of the blockages have been identified.

Floodplains

- Assessments are needed to map the entire channel migration zone/100 year floodplain throughout WRIA 20. This will help enforce regulations to protect shoreline habitat.

- Floodplain mapping is needed in all basins in WRIA 20. This should include soil mapping and elevation measurements.

- Baseline profiles should be maintained to monitor channel incision and aggradation.

- Stream mapping and typing need to be updated within WRIA 20.

Streambed and Sediment Issues

- Road surveys are needed throughout WRIA 20 to determine the best places for cross drains.

- A study is needed to assess whether road decommissioning really helps reduce sediment impacts on salmonids.

- Instream large woody debris data are needed for the Bogachiel, Lake Ozette tributaries, Sooes, and Waatch basins.

Riparian

- The studies of windthrow effects specific to the north Washington Coast need to be completed and published.
- Riparian data (tree species and age) need to be analyzed for the Bogachiel, Lake Ozette tributaries, Sooes, and Waatch basins.

Water Quality

- A study is needed to determine the effect of spalts on water quality and salmonid impacts. This should include measurements of dissolved oxygen, acidity, temperature, and macroinvertebrate populations.
- Potential water quality impacts from mills located along river banks need to be assessed.

Water Quantity

- Studies are needed to determine the effects of upland vegetation removal on increased fine sediment levels in the alluvial aquifers of floodplain watersheds.
- Studies are needed to assess the effect of reduced hydrologic maturity on salmon habitat.
- More flow gauging is needed within WRIA 20, particularly for both tributaries and mainstems.
- Studies to determine the contribution of fog drip to summer flows are needed for WRIA 20.
- Effects to and from hyporheic zones should be investigated. Wells should be installed to monitor nutrient cycling.

Biological Processes

- Inventory macroinvertebrates to assess the abundance and diversity of “fish food”.

Estuary and Near Shore

- An analysis similar to watershed analysis is needed for the Quillayute River. The emphasis should be on sedimentation and its upland sources, as well as the effects of bank protection and dredging on salmonid habitat.

- A study examining the role of small estuaries on salmonid use in needed in this WRIA.

- Studies are needed to quantify the points made in this report, especially those issues expressed by aerial photographs.

- The causes of toxic algal blooms should be examined in the near shore waters of WRIA 20.

- The effects of sedimentation on kelp beds in the near shore environments is a data need.

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GLOSSARY

Adaptive management: Monitoring or assessing the progress toward meeting objectives and incorporating what is learned into future management plans.

Adfluvial: Life history strategy in which adult fish spawn and juveniles subsequently rear in streams, but migrate to lakes for feeding as subadults and adults. Compare fluvial.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Anadromous fish: Species that are hatched in freshwater mature in saltwater, and return to freshwater to spawn.

Aquifer: Water-bearing rock formation or other subsurface layer.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Basin flow: Portion of stream discharge derived from such natural storage sources as groundwater, large lakes, and swamps but does not include direct runoff or flow from stream regulation, water diversion, or other human activities.

Bioengineering: Combining structural, biological, and ecological concepts to construct living structures for erosion, sediment, or flood control.

Biological Diversity (biodiversity): Variety and variability among living organisms and the ecological complexes in which they occur; encompasses different ecosystems, species, and genes.

Biotic Integrity: Capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region; a system's ability to generate and maintain adaptive biotic elements through natural evolutionary processes.

Biological oxygen demand: Amount of dissolved oxygen required by decomposition of organic matter.

Braided stream: Stream that forms an interlacing network of branching and recombining channels separated by branch islands or channel bars.

Buffer: An area of intact vegetation maintained between human activities and a particular natural feature, such as a stream. The buffer reduces potential negative impacts by providing an area around the feature that is unaffected by this activity.

Carrying capacity: Maximum average number or biomass of organisms that can be sustained in a habitat over the long term. Usually refers to a particular species, but can be applied to more than one.

Channelization: Straightening the meanders of a river; often accompanied by placing riprap or concrete along banks to stabilize the system.

Channelized stream: A stream that has been straightened, runs through pipes or revetments, or is otherwise artificially altered from its natural, meandering course.

Channel Stability: Tendency of a stream channel to remain within its existing location and alignment.

Check dams: Series of small dams placed in gullies or small streams in an effort to control erosion. Commonly built during the 1900s.

Confluence: Joining.

Connectivity: Unbroken linkages in a landscape, typified by streams and riparian areas.

Critical Stock: A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.

Depressed Stock: A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.

Debris torrent: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: The lowering of the streambed or widening of the stream channel by erosion. The breakdown and removal of soil, rock and organic debris.

Deposition: The settlement of material out of the water column and onto the streambed.

Distributaries: Divergent channels of a stream occurring in a delta or estuary.

Diversity: Variation that occurs in plant and animal taxa (i.e., species composition), habitats, or ecosystems. See *species richness.*

Ecological restoration: Involves replacing lost or damaged biological elements (populations, species) and reestablishing ecological processes (dispersal, succession) at historical rates.

Ecosystem: Biological community together with the chemical and physical environment with which it interacts.

Ecosystem management: Management that integrates ecological relationships with sociopolitical values toward the general goal of protecting or returning ecosystem integrity over the long term.

Endangered Species Act: A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife and plants be protected and restored.

Endangered Species: Means any species which is in endanger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta as determined by the Secretary to constitute a pest whose protection under would provide an overwhelming and overriding risk to man.

Escapement: Those fish that have survived all fisheries and will make up a spawning population.

Estuarine: A partly enclosed coastal body of water that has free connection to open sea, and within which seawater is measurably diluted by fresh river water.

Eutrophic: Water body rich in dissolved nutrients, photosynthetically productive, and often deficient in oxygen during warm periods. Compare *oligotrophic*.

Evolutionary Significant Unit (ESU): A definition of a species used by National Marine Fisheries Service (NMFS) in administering the Endangered Species Act. An ESU is a population (or group of populations) that is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species.

Extirpation: The elimination of a species from a particular local area.

Flood: An abrupt increase in water discharge.

Floodplain: Lowland areas that are periodically inundated by the lateral overflow of streams or rivers.

Flow regime: Characteristics of stream discharge over time. Natural flow regime is the regime that occurred historically.

Fluvial: Pertaining to streams or rivers; also, organisms that migrate between main rivers and tributaries. Compare *adfluvial*.

Gabion: Wire basket filled with stones, used to stabilize streambanks, control erosion, and divert stream flow.

Genetic Diversity Unit (GDU) is defined as: A group of genetically similar stocks that is genetically distinct from other such groups. The stocks typically exhibit similar life histories and occupy ecologically, geographically and geologically similar habitats. A GDU may consist of a single stock

Geomorphology: Study of the form and origins of surface features of the Earth.

Glides: Stream habitat having a slow, relatively shallow run of water with little or no surface turbulence.

Healthy Stock: A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.

Hydrograph: Chart of water levels over time.

Hydrology: Study of the properties, distribution, and effects of water on the Earth's surface, subsurface, and atmosphere.

Intermittent stream: Stream that has interrupted flow or does not flow continuously. Compare *perennial stream*.

Intraspecific interactions: Interactions within a species.

Large Woody Debris (LWD): Large woody material that has fallen to the ground or into a stream. An important part of the structural diversity of streams. LWD is also referenced to as "coarse woody debris" (CWD). Either term usually refers to pieces at least 20 inches (51 cm) in diameter.

Limiting Factor: Single factor that limits a system or population from reaching its highest potential.

Macroinvertebrates: Invertebrates large enough to be seen with the naked eye (e.g., most aquatic insects, snails, and amphipods).

Mass failure: Movement of aggregates of soil, rock and vegetation down slope in response to gravity.

Native: Occurring naturally in a habitat or region; not introduced by humans.

Non-Point Source Pollution: Polluted runoff from sources that cannot be defined as discrete points, such as areas of timber harvesting, surface mining, agriculture, and livestock grazing.

Parr: Young trout or salmon actively feeding in freshwater; usually refers to young anadromous salmonids before they migrate to the sea. See *smolt*.

Plunge pool: Basin scoured out by vertically falling water.

Rain-on-snow events: The rapid melting of snow as a result of rainfall and warming ambient air temperatures. The combined effect of rainfall and snow melt can cause high overland stream flows resulting in severe hillslope and channel erosion.

Rearing habitat: Areas required for the successful survival to adulthood by young animals.

Recovery: The return of an ecosystem to a defined condition after a disturbance.

Redds: Nests made in gravel (particularly by salmonids); consisting of a depression that is created and the covered.

Resident fish: Fish species that complete their entire life cycle in freshwater.

Riffle: Stream habitat having a broken or choppy surface (white water), moderate or swift current, and shallow depth.

Riparian: Type of wetland transition zone between aquatic habitats and upland areas. Typically, lush vegetation along a stream or river.

Riprap: Large rocks, broken concrete, or other structure used to stabilize streambanks and other slopes.

Rootwad: Exposed root system of an uprooted or washed-out tree.

SASSI: Salmon and Steelhead Stock Inventory.

SSHIAP: A salmon, steelhead, habitat inventory and assessment program directed by the Northwest Indian Fisheries Commission.

Salmonid: Fish of the family salmonidae, including salmon, trout chars, and bull trout.

Salmon: Includes all species of the family Salmonid

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Sedimentation: The process of sediment being carried and deposited in water.

Side channel: A portion of an active channel that does not carry the bulk of stream flow. Side channels may carry water only during high flows, but are still considered part of the total active channel.

Sinuosity: Degree to which a stream channel curves or meanders laterally across the land surface.

Slope stability: The degree to which a slope resists the downward pull of gravity.

Smolt: Juvenile salmon migrating seaward; a young anadromous trout, salmon, or char undergoing physiological changes that will allow it to change from life in freshwater to life in the sea. The smolt state follows the parr state. See *parr*.

Stock: Group of fish that is genetically self-sustaining and isolated geographically or temporally during reproduction. Generally, a local population of fish. More specifically, a local population – especially that of salmon, steelhead (rainbow trout), or other anadromous fish – that originates from specific watersheds as juveniles and generally returns to its birth streams to spawn as adults.

Stream order: A classification system for streams based on the number of tributaries it has. The smallest unbranched tributary in a watershed is designated order 1. A stream formed by the confluence of 2 order 1 streams is designated as order 2. A stream formed by the confluence of 2 order 2 streams is designated order 3, and so on.

Stream reach: Section of a stream between two points.

Stream types:

> Type 1: All waters within their ordinary high-water mark as inventoried in "Shorelines of the State".
>
> Type 2: All waters not classified as Type 1, with 20 feet or more between each bank's ordinary high water mark. Type 2 waters have high use and are important from a water quality standpoint for domestic water supplies, public recreation, or fish and wildlife uses.
>
> Type 3: Waters that have 5 or more feet between each bank's ordinary high water mark, and which have a moderate to slight use and are more moderately important from a water quality standpoint for domestic use, public recreation and fish and wildlife habitat.
>
> Type 4: Waters that have 2 or more feet between each bank's ordinary high water mark. Their significance lies in their influence on water quality of larger water types downstream. Type 4 streams may be perennial or intermittent.
>
> Type 5: All other waters, in natural water courses, including streams with or without a well-defined channel, areas of perennial or intermittent seepage, and natural sinks. Drainage ways having a short period of spring runoff are also considered to be Type 5.

Sub Watershed: One of the smaller watersheds that combine to form a larger watershed.

Thalweg: Portion of a stream or river with deepest water and greatest flow.

Watershed: Entire area that contributes both surface and underground water to a particular lake or river.

Watershed rehabilitation: Used primarily to indicate improvement of watershed condition or certain habitats within the watershed. Compare *watershed restoration*.

Watershed restoration: Reestablishing the structure and function of an ecosystem, including its natural diversity; a comprehensive, long-term program to return watershed health, riparian ecosystems, and fish habitats to a close approximation of their condition prior to human disturbance.

Watershed-scale approach: Consideration of the entire watershed in a project or plan.

Weir: Device across a stream to divert fish into a trap or to raise the water level or divert its flow. Also a notch or depression in a dam or other water barrier through which the flow of water is measured or regulated.

Wild Stock: A stock that is sustained by natural spawning and rearing in the natural habitat regardless.